Reports File

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RESEARCH PROJECT INITIATION

Date: 8 June 1973

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Project No: C-11-608

Principal Investigator Dr. Harold E. Smalley

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Assigned to: HSRC

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RA-3 (6-71)

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF RESEARCH ADMINISTRATION

RESEARCH PROJECT TERMINATION

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Project Title: A [illegible] for [illegible] Medical Systems

Project No: [illegible]-11-[illegible]

Principal Investigator: [illegible]

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RA-4 (5/70)

Programmed Planning Guide to Determine

Ambulance Placement Strategies For Emergency Medical Systems

Developed by the
Health Systems Research Center

Under Grant No. R18 HS 00715-02
Division of Health Services Research Analysis
Bureau of Health Services Research
Health Resources Administration
Department of Health, Education, and Welfare

Health Systems Research Center
Georgia Institute of Technology
Atlanta January 1974

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SELECTED HSRC REPORTS

Various publications of the Health Systems Research Center are available in either hard copy or microfilm from University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106. When ordering a publication from the list below, refer to the appropriate Hospital Abstract number.

Ambulance Placement Strategies for Emergency Medical Systems, USPHS Grant No. R18 HS 00715-02, January 1974, 133 pp. (Hospital Abstract #11601 HE).

Curricula in Health Systems Progress Report for 1973-74, Allied Health Professions Special Training Project Grant No. D12 AH 00242-01, December 1973, 48 pp. (Hospital Abstract #11600 HE).

Dental Manpower Planning: A Systems-Analytic View, Program Bulletin No. 8, USPHS Grant No. D02 AH 01056, May 1973, 285 pp. (Hospital Abstract #10250 MP).

An Improved Emergency Medical System for Metropolitan Atlanta, A Comprehensive Plan and Systems Design, Final Report to the Georgia Regional Medical Program, March 1973, 566 pp. (Hospital Abstract #10150 OU).

Program in Hospital and Medical Systems Final Report and Evaluation, USPHS Grant No. D02 AH 01056, February 1973, 238 pp. (Hospital Abstract #10050 MN).

Fiscal Controls for Hospital Departments, Program Bulletin No. 7, USPHS Grant No. D02 AH 01056, October 1972, 203 pp. (Hospital Abstract #09499 AC).

Analysis of Optimal Radiographic Location Networks, Final Report, USPHS Grant No. HS 00179, October 1971; Vol. I, II, III, and Parts 1-4 of Vol. IV, total of 565 pp. (Hospital Abstracts #RLO-7441 through #RLO-7447).

Systems Analysis of Medical Records in Georgia, Final Report, USPHS Contract No. HSM 110-70-349, September 1971; Vol. I, II, and III, total of 518 pp. (Hospital Abstracts #MRO-7741 through #MRO-7743).

The Planning of Clinical Facilities for Medical Education: A Systems Approach, Program Bulletin No. 6, USPHS Grant No. D02 AH 01056, August 1970, 349 pp. (Hospital Abstract #MD2-5900).

Quantitative Methods for Evaluating Hospital Designs, Program Bulletin No. 5, Final Report, NCHSRD Research Grant No. HM 00529, August 1969, 239 pp. (Hospital Abstract #DE 1026).

Hospital Management Systems Analyst Training Program, Final Report, W. K. Kellogg Foundation Grant, August 1966, 67 pp. (Hospital Abstract #PE 2015).

Disposable Versus Reprocessed Hospital Supplies, Final Report, USPHS Research Grant No. GN 5968, June 1964, 77 pp. (Hospital Abstract #45).

AMBULANCE PLACEMENT STRATEGIES
FOR
EMERGENCY MEDICAL SYSTEMS

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A Programmed Planning Guide
developed by the
Health Systems Research Center

Under Grant No. R18 HS 00715-02

(Harold E. Smalley, Ph.D., Principal Investigator)

Division of Health Services Research Analysis
Bureau of Health Services Research
Health Resources Administration
Department of Health, Education, and Welfare

Health Systems Research Center
Georgia Institute of Technology
Atlanta January 1974

FOREWORD

The present document is a guide for use by emergency medical planners in determining ambulance placement strategies. This "Guide" was created by the Health Systems Research Center to be a tool in the design of new or improved emergency medical systems, and it utilizes readily obtainable data to determine the appropriate number of ambulances and their locations in any geographical area. Procedures within the Guide permit the user to specify desired response time and ambulance availability constraints.

This is the first of a series of outputs from an HSRC project supported since 1972 by a grant from the Bureau of Health Services Research. The project was originally conceived to be an attempt to develop an EMS simulation model. However, reviews of several working papers generated during the first year demonstrated to both the research team and the Bureau the need to redirect project objectives toward the subjects of ambulance location, telemetry, and data collection methodologies. Accordingly, subsequent reports from this project, to be released during 1974, will deal with these new latter topics.

EMS has been a major area of interest within HSRC since early 1969 when the Metropolitan Atlanta Council for Health (MACHealth) established its Task Force on Emergency Health Services. The MACHealth Task Force was charged with the responsibility of identifying problems associated with the provision of emergency medical services in the metropolitan Atlanta area. HSRC participated actively on the Task Force, provided technical systems capabilities, and prepared a number of research, planning, and design proposals for and with MACHealth, which in 1972 became a division of the Atlanta Regional Commission (ARC).

HSRC was commissioned by ARC in 1972 to develop a comprehensive plan and systems design for an improved emergency system for metropolitan Atlanta. This work was done by HSRC under a contract with the Georgia Regional Medical Program and was completed in March 1973. The resulting plan, described in a 566-page report, includes requirements for number, types, and geographical positioning of emergency vehicles; a recommendation of an organization for coordination, operation, and control of the EMS system components; a communications subsystem design; a comprehensive set of procedures for performing the dispatch and control function; recommendations for training EMS personnel; a scheme for evaluating EMS system performance; and recommendations for financing the EMS system.

The Guide described in the present document builds upon these EMS experiences, it responds to interest expressed by the Bureau of Health Services Research, and it partially fulfills an unmet need in the field of health planning.

Harold E. Smalley, Ph.D.
Principal Investigator

PREFACE

Within reference publications dealing with emergency medical services there exist a number of informational gaps that either fail to discuss vital subjects or address them in such a highly technical fashion that the information is decipherable to only a few persons. Addressing some of the aforementioned inadequacies, the Guide presented in this report provides valuable insight into the engineering aspects of emergency ambulance placement in a manner that can be clearly understood and applied. The Guide is written for the EMS planner and, unlike most other EMS reference publications, is written <u>to</u> the EMS planner.

The Guide is a self-contained methodology containing discrete subsections to which the user is referred through a series of programmed instructions. The Guide is designed to be used as a tool. Tabulation space is provided, and, through the programmatical format, the user may choose and apply the method of analysis most appropriate to the community for which the ambulance location strategy is being developed.

This report presents a complete final version of the Guide, assembled in a conventional research report format. Although the present document is appropriate for professional review and library storage, the Guide should be re-assembled before it is used as a tool. Adherence to the programmed instructions of the Guide as it is presently assembled would be cumbersome, and significant distractions could result. The proposed final assembly to enhance the Guide's utility as a tool for the health planner is described further, and is illustrated in an appendix of this report.

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LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

This reference guide will assist you, the health planner, to develop an emergency care system that utilizes geographically distributed emergency ambulances. The following pages rely upon population (census) data from the community in question to determine how many emergency ambulances are required, and where they should be placed. This Guide is applicable if you have no system at the present time, even though some independent ambulance services may exist. The Guide may be used if you wish to redesign an existing system and are constrained by having only limited data available.

The ambulance subsystem of an emergency medical service is defined herein as the component of an emergency service that functions to transport medical aid to the victim of a medical emergency. The Guide presupposes that ambulance staff are appropriately trained, able to stabilize the patient on the scene and required to speed to hospitals only in rare cases. The Guide does not locate ambulances as a function of the distance between the ambulance and hospitals. Dispatching, training, communications, and other emergency service subsystems related to ambulances also require attention, but their complexities demand separate study and, therefore, they are not addressed in this Guide. Several of these peripheral topics are thoroughly discussed in publications available from other sources.

This present Guide is written to describe the process by which you determine where to locate ambulances. The Guide does not describe the mathematical, theoretical, or historical justification for its method, although the appendices present some mathematical proofs, and several references are available and documented. This Guide may be used to design systems dedicated to servicing only emergency demand or to plan for emergency and non-emergency utilization of ambulances. The use of special vehicles will not influence the results obtained by applying this Guide since special vehicles serve to augment rather than alter the emergency ambulance function.

Many emergency medical services throughout the United States utilize a group of ambulances which are stationed at one central location while awaiting assignment. This one-location configuration is not necessarily improper, but the spacial characteristics of demand must be measured before the merit of a one-location system can be accurately appraised.

There are two basic parameters upon which decisions regarding the number and location of ambulances should be predicated. The first, referred to as "immediate availability," describes the frequency or per cent of time that all ambulances are not busy. If the decision regarding the placement of ambulances has been made, application of the availability criterion will tell you how many ambulances should be placed at each location.

The second significant parameter describes "response time," or how long it takes for the ambulance to arrive. Response time is usually defined as the elapsed time between the receipt of a request for service and the arrival of the ambulance at the scene of the emergency. Response time is illustrated in Figure 1.

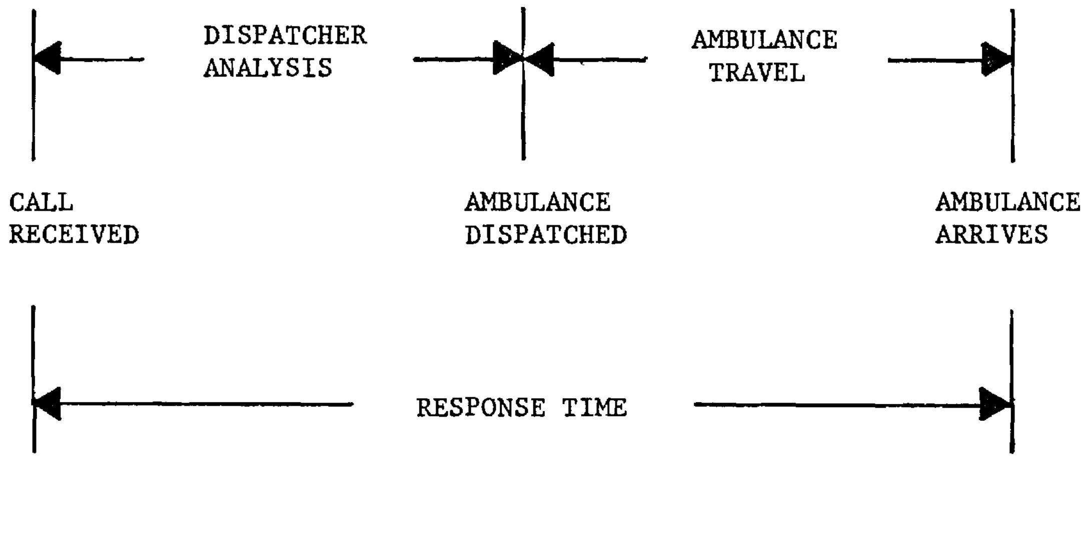

FIGURE 1 Response Time Illustration

Dispatcher analysis, illustrated in Figure 1, is the time required by the dispatcher to receive information from the caller, choose the appropriate ambulance, and perform the actual dispatch tasks. The time required for dispatcher analysis varies considerably, but can be calculated if records exist, or estimated if no records are available.

Ambulance travel time may also vary considerably, as a function of the weather, traffic jams, and between urban and rural areas. This Guide does not deal with the weather, but urban or rural speeds may be practically determined and considered. Rush-hour traffic jams are not addressed in the Guide calculations. Rush-hour periods probably occur only twice per day, for a few hours and therefore have little influence upon total system performance. In addition, emergency vehicles are frequently able to travel through heavy traffic by violating lane markers or leaving the roadway, further reducing the significance of rush-hour traffic with respect to total system performance.

This background information should provide you with the basic insights necessary to proceed with the actual determination of your community's ambulance needs. The Guide is presented in a logical sequence which must be followed. Some calculations may yield erroneous results if they are performed out of sequence. All important issues are addressed, and a special set of tabulation worksheets are provided.

GUIDE SECTION

Instructions to the User

For convenience and continuity, this reference guide is divided into four sections: Guide, Reference, Example, and Tabulation. The Guide Section is a control mechanism for the reference manual. As you read the Guide Section you will be referred to the other sections for supplementary explanations, computational recordings, and examples. The Guide pages, as the core of the reference manual, must be utilized in the proper sequence. This fact cannot be overemphasized, because only by following the instructions in the order described in the Guide Section will you be able to obtain valid answers to the number and location of ambulances for your EMS system. Any deviation from the sequential steps will result in erroneous answers or no answers at all.

Programmed Guide Pages

Service System Area

Immediate availability calculations and response times are a function of the demand for service which is a function of the population to be served. The population to be served is, to a large extent, directly related to the area to be serviced by the system of ambulances. This area and its boundaries must be defined.

Step 1: Choose one of the following and work through the Guide as described below.

Statewide System. This Guide cannot be applied directly to a statewide system. The state must be divided into regions. Reference page R1 describes a method for dividing the state into regions and the appropriate procedure to follow when completing the remaining sections of the Guide. If you are planning a Statewide System turn to Reference page R1.

True Regional System. The regional system of ambulances is defined herein as a system which serves a city and surrounding counties, or more than one county in a rural area. If the system is truly regional, ambulances will routinely respond to a request for service anywhere within the region regardless of the county or city in which the emergency occurs. If you select a true regional system work through the Guide as if the region were a county. See the County System instructions below.

Note: Before you place your system into this category, read the Mutual Assistance Regional System definition.

Mutual Assistance Regional System. This system serves a city and surrounding counties, or more than one county in a rural area. However, ambulances are assigned primarily to one county or another and do not routinely cross political boundaries. If your system will be a Mutual Assistance Regional System identify (on a map) each ambulance subsystem service area* by a letter or number and turn to Guide page G3.

Note: If you are in a position to choose between a True or Mutual Assistance Regional System turn to Reference page R2.

County System. The County System is a system of ambulances serving one county. If this category describes your proposed system turn to Guide page G2.

City System. The City System is a system of ambulances serving one city. If this category describes your proposed system turn to Guide page G2.

Step 2: After choosing a method turn to the appropriate page (described above).

---

* The ambulance subsystem service areas may be counties, cities, or other subdivisions. For example, in the County System, there is one ambulance subsystem service area--the county.

Guide Procedures

You have chosen a True Regional System, a County System, or a City System, and having done so you must adhere to special rules throughout the Guide. The Guide is presented in a format designed for planning the Mutual Assistance Regional System (MARS). The Guide's format was chosen to accommodate the MARS calculations which require more tabulation space than any of the other alternatives. When working through the Guide you will notice that, on occasion, ten spaces are provided to allow the user to design up to ten ambulance subsystems at once. Unless your area has both rural and urban sub-areas, you have only one total system and no subsystems and, therefore, may not be required to utilize all tabulation spaces. This point is offered only for clarity--the Guide will accommodate your needs. Turn to Guide page G3.

The Approach for Solving the Problem

Before you proceed with the ambulance location problem a decision must be made. There are a few basic approaches to solving the ambulance location problem. The method that you choose will determine how you utilize relevant data, and will also determine the sequence you will follow when completing the Guide.

Step 1: Turn to Reference page R3 to review the alternatives before you indicate your method below.

Step 2: Indicate your method below, for your own reference.

Method 1: The response time for a primary ambulance will usually not exceed a maximum criterion target value, a primary ambulance will be available immediately for a criterion target per cent of the time, and dependency upon secondary ambulances is minimized.

Method 2: The response time for a primary ambulance will usually not exceed a maximum criterion target value, a primary or secondary ambulance will be available immediately for a criterion target per cent of the time, and dependency upon secondary ambulances is not minimized.

Method 3: The response time for a primary ambulance will usually not exceed an average criterion target value, a primary ambulance will be available immediately for a criterion target per cent of the time, and dependency upon secondary ambulances is minimized.

Method 4: The response time for a primary ambulance will usually not exceed an average criterion target value, a primary or secondary ambulance will be available immediately for a criterion target per cent of the time, and dependency upon secondary ambulances is not minimized.

Step 3: Turn to Guide page G4.

Guide Sequence

At the top of some Guide pages, beginning with page G5, is a space for the appropriate "Sequence Number." Fill in the appropriate sequence numbers on the pages as shown below in Table 1.

TABLE 1 Guide Page Sequence Numbers.

Guide Page	Sequence Number			
	Method 1	Method 2	Method 3	Method 4
5	1	1	1	1
6	2	2	2	2
7	3	3	Not Applicable	Not Applicable
8	Not Applicable	Not Applicable	3	3
9	4	4	4	4
10	5	5	5	5
11	6	6	Not Applicable	Not Applicable
12	Not Applicable	Not Applicable	6	6
13	7	7	7	7
14	8	8	8	8
15	Not Applicable	9	Not Applicable	9
16	Not Applicable	10	Not Applicable	10
17	Not Applicable	Not Applicable	Not Applicable	11
18	Not Applicable	11	Not Applicable	Not Applicable
19	Not Applicable	Predetermined	Not Applicable	Not Applicable
20	Not Applicable	Predetermined	Not Applicable	Not Applicable
21	Not Applicable	Predetermined	Not Applicable	Predetermined
22	Not Applicable	Predetermined	Not Applicable	Predetermined
23	9	Predetermined	9	Predetermined
24	Predetermined	Predetermined	Predetermined	Predetermined
25	Predetermined	Predetermined	Predetermined	Predetermined
26	Predetermined	Predetermined	Predetermined	Predetermined

Step 1: After you fill in appropriate Sequence numbers throughout the Guide, turn to Sequence page 1.

Subsystem Area Identification

To facilitate computations each subsystem service area must be identified with a number.

Step 1: Does your system service area include both rural and urban areas?

Yes: If you answered "yes" to the question you must identify (on a map) each urban and rural sub-area within each subsystem service area. You may wish to refer to Reference page R1 for assistance. Before performing this task proceed with Step 2 (below).

No: If you answered "no" to the question proceed with Step 2 (below).

Step 2: Turn to Example page E1.

Step 3: Identify each subsystem service area by number and proceed with Step 4.

Step 4: Complete column 1, 2, and 3 on Tabulation page T1 after reviewing the example on Example page E2. Turn to Example page E2.

Step 5: Turn to the next sequence page.

Response Time and Average Speed

You must choose a target response time for your system. Several important insights to this non-technical problem are provided on Reference page R4. Turn to Reference page R4.

Step 1: Turn to Tabulation page T1, instruction 5.

Step 2: The average speed is defined as the average speed that the ambulance will travel when responding to an emergency. In urban areas this speed will equal approximately 30 miles per hour, and in rural areas this speed will fall within the range of 40-55 miles per hour (1,p.93). You may determine the average speed for your system by following the method outlined on Reference page R5, or you may use the estimates presented above. Your local police or ambulance authorities may be consulted to verify estimates for your area.

Determine or estimate the average speed for each area in your system, and turn to Tabulation page T1, instruction 8.

Step 3: Turn to the next sequence page.

Initial Estimates for Ambulance Location - Graphic Aids for Method 1 or 2

This page should be used only if you are applying Method 1 or Method 2 (described on Guide page G3). Initial estimates for ambulance locations are determined by calculating the radius of each ambulance response district, preparing graphic aids with which to work, and placing the ambulance response districts onto a map so that all segments of the population fall within at least one ambulance response district.

Step 1: Obtain a blank sheet of paper and a compass (of the circle drawing variety). The paper will be used to construct circles which will be used as templates for drawing other circles, and should be heavy enough to allow for repeated use. On Tabulation page T1, in column seven (7), are the figures you should use as the radius of the response district circles. Draw one response district circle for each area or sub-area listed on Tabulation page T1, using the appropriate radius (column 7) and a scale that corresponds to that of the map which you are using.* As you draw each circle label it with the Identification Symbol found in column three (3) on Tabulation page T1.

Step 2: When you complete this task, turn to the next sequence page.

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* A large scale map showing all service areas and census tracts.

Initial Estimates for Ambulance Location - Graphic Aids for Method 3 or 4

This page should be used only if you are applying Method 3 or Method 4 (described on Guide page G3). Initial estimates for ambulance locations are determined by calculating the radius of each ambulance response district, preparing graphic aids with which to work, and placing the ambulance response districts onto a map so that all segments of the population fall within at least one ambulance response district.

Your problem solution method utilizes an ambulance response district radius equal to the maximum distance that an ambulance can travel and maintain an average criterion response time. An additional calculation is required to determine the response district radius. Turn to Tabulation page T2.

Step 1: Obtain a blank sheet of paper and a compass (of the circle drawing variety). The paper will be used to construct circles which will be used as templates for drawing other circles, and should be heavy enough to allow for repeated use. On Tabulation page T2, in column three (3), are the figures you should use as the radius of the response district circles. Draw one response district circle for each area or sub-area listed on Tabulation page T2, using the appropriate radius (column 3) and a scale that corresponds to that of the map which you are using.* As you draw each circle label it with the Identification Symbol found in column one (1) on Tabulation page T2.

Step 2: When you complete this task, turn to the next sequence page.

---

* A large scale map of the service area(s) showing population density.

Initial Estimates for Ambulance Location - Using the Map

As a first approximation to placing ambulances at appropriate locations in each service area a graphic technique can be used. If you are applying Method 3 or 4 you should obtain a large scale map of the service area(s) showing population density. If population density maps are not available or if you are applying Method 1 or 2, any large scale map will suffice.

Use the graphic aids, prepared in the previous step, to draw response districts on the map, as described below.

Step 1: If you have not already done so, draw and label each service area on the map (see Example page E1).

Step 2: Obtain the paper disc appropriate for the area with which you will begin analysis.

Step 3: The circular response districts will be drawn using the paper disc as a template. If you are applying Method 1 or 2 you will draw the response districts to include all of the system service area.* If you are applying Method 3 or 4 you will draw the response districts to include most of the population and area. Turn to Example page E3 and review the illustrations.

Step 4: Draw response districts for each service area.

Step 5: Identify each response district within each subsystem service area with a number, beginning with the number "1". If your system has more than one subsystem service area start over with the number "1" in each subsystem service area. Review the numbering scheme on Example page E3, before proceeding.

Step 6: Complete column one (1) on Tabulation page T3 after reviewing an example. Turn to Example page E5.

Step 7. Turn to the next sequence page.

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* Some response district overlap is tolerable, and failure to provide target response time coverage for small segments of the area is also tolerable at the cost of not being able to serve people in these areas within criterion target performance values.

Census Tract Adjustment of Response Districts/Calculations

In order to calculate the response time of each ambulance, the population and its distribution in each response district must be determined. Most available data describe population by census tract. Therefore, you must revise the circular response districts slightly to conform to census tract boundaries when possible. When this procedure results in a gross distortion of the response districts, the census tract(s) may be divided and each portion of the tract assigned appropriately fewer inhabitants.

Step 1: Turn to Example page E6 to review the example.

Step 2: Adjust your response districts to conform to census tract boundaries, and proceed with Step 3.

Step 3: Ten Tabulation pages (T4 through T13) are provided for the required calculations; one for each subsystem service area. If you have more than ten subsystem service areas, duplicate page T13. If you have fewer than ten subsystem service areas, begin on page T4 and use only those pages that are required for your system. The instructions for completing these Tabulation pages are presented on page T4. Review the example on Example page E7 before you proceed. Turn to Example page E7.

Step 4: Turn to the next sequence page.

Response Distance Calculations/District Adjustments for Method 1 or 2

On Tabulation pages T4 through T13, in column eight (8) you placed one entry for each response district. This figure represents the miles (air miles) traveled to reach the "average" person. On Tabulation page T1, in column seven (7), you calculated the maximum distance acceptable in your system. You must compare all column eight (8) entries on Tabulation pages T4 through T13 to the appropriate entry in column seven (7) on Tabulation page T1.* If any of the values in column eight (8) (pp. T4-T13) exceed the maximum acceptable values (p. T1) you must redefine your response districts (those with unacceptable distances and the adjacent districts) before proceeding. You may find it necessary to add a response district in some cases.

Step 1: Review your calculated response distances from Tabulation pages T4 to T13 and adjust the districts if necessary. If you add any response districts adjust the entry in column one (1) on Tabulation page T3 accordingly.

Step 2: The only reliable method for evaluating your revised district configuration is to repeat the distance calculation process, but only for districts whose boundaries have been revised. Turn to Tabulation page T4, instruction 1, if revisions are necessary. If not proceed with step 3, below.

Step 3: Turn to the next sequence page.

* The "appropriate" entry is the entry in column seven (7) on page T1 for the subsystem service area in which the response district in question is located.

Response Distance Calculations/District Adjustments for Method 3 or 4

On Tabulation pages T4 through T13, in column eight (8) you placed one entry for each response district. This figure represents the average miles (air miles) traveled to reach the "average" person. On Tabulation page T2, in column three (3), you calculated the maximum distance acceptable in your system. You must compare all column eight (8) entries on Tabulation pages T4 through T13 to the appropriate entry in column three (3) on Tabulation page T2.* If any of the values in column eight (8) (pp. T4-T13) exceed the maximum acceptable values (p. T2) you must redefine your response districts (those with unacceptable distances and the adjacent districts) before proceeding. You may find it necessary to add a response district in some cases.

Step 1: Review your calculated response distances from Tabulation pages T4 to T13 and adjust the districts if necessary. If you add any response districts adjust the entry in column one (1) on Tabulation page T3 accordingly.

Step 2: The only reliable method for evaluating your revised district configuration is to repeat the distance calculation processes, but only for districts whose boundaries have been revised. Turn to Tabulation page T4, instruction 1, if revisions are necessary. If not proceed with step 3, below.

Step 3: Turn to the next sequence page.

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* The "appropriate" entry is the entry in column three (3) on page T2 for the subsystem service area in which the response district in question is located.

Immediate Availability Calculations - Service Time

Regardless of the method you have chosen, calculations will be required to determine the number of ambulances required in order to satisfy the per cent immediate availability criteria. The mathematical relationships associated with determining the required number of ambulances in each district are complex. However, in this Guide, most calculations have been performed for you. You must provide only a few quantities which include:

(1) Service time - The length of time required for an ambulance to respond, treat the victim, transport the victim, and return to the district.
(2) Demand - Calculated from population data.
(3) Per cent immediate availability - The criterion per cent of time that an ambulance will be immediately available.

Service time, as defined above, for most systems appears to average approximately sixty minutes. You may measure the average service time in your area, or you may accept this estimate. If you wish to measure the service time, turn to Reference page R6 for assistance. If you are providing emergency service, but rely upon others to transport the victim to a hospital, turn to Reference page R6.

Step 1: Record the determined service time, in minutes, on Tabulation page T14.

Step 2: Turn to the next sequence page.

Per Cent Immediate Availability

The calculations performed for you in this guide are based upon three criterion per cent immediate availability alternatives. The first, and most common figure, produces a system in which an ambulance will be immediately available 90 per cent of the time.* The second choice is 95 per cent, and the third is 99 per cent. You must choose one of these alternatives.

The decision is political. A system with 99 per cent immediate availability will require more ambulances than an identical system with 90 per cent immediate availability. The difference, measured in ambulances, at an annual cost of over $70,000 each, is not 9% as would appear to be the case. The difference depends upon many characteristics of the system. In Fulton County, Georgia, for example, a "90 per cent" system requires 6 ambulances and a "99 per cent" system would require 9 ambulances.** In Clayton County, Georgia, the "90 per cent" system requires 2 ambulances and the "99 per cent" system would require 3 ambulances.**

Step 1: Record the determined criterion per cent (90, 95, or 99) on Tabulation page T14, instruction 3, before proceeding with the next step.

Step 2: Turn to the next sequence page.

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* Thomas A. Hulfish, President of Paramed, Inc., states that "immediate availability of ambulances in an EMS should be 90% or above." Keith Stevenson, in Operational Aspects of Emergency Ambulance Services states that "we should like to keep the probability of a dispatch delay as low as possible." Dunlap and Associates in Economics of Highway Emergency Ambulance Services use a value of 90% immediate availability.

** Figures are based only upon immediate availability criteria, using 1970 U.S. Bureau of the Census figures for the Atlanta S.M.S.A.

Demand and Immediate Availability Calculations - Method 2 or 4

System demand, defined as the number of requests for emergency service within a period of time is, for the purposes of this Guide, a function of population size. In fact, demand is a function of the socio-economic characteristics of the population, terrain, weather, and several other factors. Computer programs have been developed to simulate demand, but population size provides an adequate estimate for planning purposes.

Since you have chosen a system in which ambulances are free to service any request within the subsystem service area, only one evaluation must be performed for each subsystem service area.

Step 1: You are working on Guide page G15. Turn to Tabulation page T17.

Step 2: This step must be performed once for each entry in column five (5) on Tabulation page T17. Using the first entry from column (5), perform the following tasks:

a) On Tabulation page T15, in the column corresponding to the criterion per cent you have chosen (90, 95, or 99), locate the number that equals, or is closest to, but greater than, the entry from column (5).
b) Read across the chart horizontally to the left margin, column "x".
c) The number in column "x" is the minimum number of ambulances required in the subsystem service area corresponding to the entry from column (5) on Tabulation page T17.
d) Turn to Tabulation page T3, instruction 6.
e) Repeat steps a-d until all subsystem service areas have been analyzed, and proceed to step 3.

Step 3: Turn to the next sequence page.

Immediate Availability Adjustments

You must examine the results of your immediate availability calculations next. Review steps 1 and 2 before performing step 1.

Step 1: Turn to Tabulation page T3 and compare the "total" lines in column two (2) and column one (1) for each subsystem service area listed on all Tabulation pages T3. You are comparing a minimum number of ambulances required to the total districts required.

Step 2: If the "total" in column two (2) is greater than the "total" in column one (1) proceed to step 3 (below). If the "totals" are equal, or the "total" in column one (1) is greater than the "total" in column two (2), proceed to step 6 (below).

Step 3: Additional ambulances are required if you are to guarantee the desired immediate availability. Subtract the column one (1) total from the column two (2) total to determine the number of additional ambulances required.

Step 4: From column five (5) for the appropriate subsystem service area identified on Tabulation pages T4 through T13, determine which response district has the greatest population and place the first required additional ambulance in that district. If additional ambulances are required place the next additional ambulance into the response district with the second highest population, the next into the district with the third highest population, and so forth, until all additional ambulances have been located.*

Step 5: Record your choice of locations. Turn to Tabulation page T3, instruction 7.

Step 6: Turn to the next sequence page.

* If you do not have enough districts to equally distribute all required additional ambulances place a second additional ambulance in the district with the highest population, next highest, etc.

Response Time Evaluation - Method 4

Your system may be considerably less expensive as a result of your decision to allow ambulances to service any request for service, as opposed to servicing only one district. However, when an ambulance responds from outside of the district in which the emergency occurs the response time increases. Additional analysis is required to be sure that response time for each subsystem service area is acceptable, given that some ambulances will be responding from an adjoining district.

Since you are working with averages you will calculate one value to represent the average response time in each subsystem service area or sub-area. As a by-product of your calculations you will determine the average response distance for each district.

Step 1: You are working on Guide page G17. Turn to Tabulation page T14, instruction 5.

Step 2: Turn to Tabulation page T4, instruction 17.

Step 3: Compare the calculated response time for each subsystem service area or sub-area with the criterion response time in column four (4) on Tabulation page T1. If any of the calculated response times from Tabulation pages T4-T13 exceed the target response time on Tabulation page T1, proceed to step 4, below. If all calculated response times are acceptable proceed to step 8, below.

Step 4: Additional ambulances are required if you are to guarantee the desired response time. On Tabulation pages T4 through T13, in the subsystem service area(s) with unacceptable response time, determine which ambulance response district has the smallest value in the column nine (9).

Step 5: Change the value in column nine (9) to the number "1", and for the subsystem service area in question repeat instructions 14, and 19-25 as necessary on Tabulation page T4. Note: You have assigned an additional ambulance to the district.

Step 6: Is the response time now acceptable? If yes, proceed to Step 7, below. If not, repeat steps 4 and 5 above, but add an ambulance to the district with the column nine (9) entry greater than the last entry and smaller than the others.

Step 7: Turn to Tabulation page T3 and update column three (3), then proceed to step 8.

Step 8: Turn to Guide page G23, step 3.

Response Time Evaluation - Method 2

Your system may be considerably less expensive as a result of your decision to allow ambulances to service any request for service, as opposed to servicing only one district. However, when an ambulance responds from outside of the district in which the emergency occurs the average response time for that district increases. In addition, as described on Reference page R3, secondary ambulance response time nearly always exceeds the target maximum. Additional analysis is required to be sure that response time for each district is acceptable, given that some ambulances will be responding from an adjoining district.

There are two methods of analysis available to you. The first method examines only the response time for secondary ambulances, and compares the determined response time against a criteria for secondary ambulances. The second method of evaluation identifies the average response time for each district and reflects the response time for both primary and secondary ambulances, stated as an average. If you use this second evaluation method you are reminded that secondary ambulance response times may often exceed the primary response time maximum target even if the average response time does not.

If you will determine and evaluate the response time for secondary ambulances only, turn to Guide page G19.

If you will determine the average response time for each distict, to reflect primary and secondary ambulance response, turn to Guide page G21.

Evaluation of Secondary Ambulance Response Times

Prior to the evaluation you must establish a maximum target response time for secondary ambulances. You have identified a maximum target value for primary ambulances. The Method 2 discussion on Reference page R3 explained that the secondary ambulance response time would be greater than or equal to the primary target value, and less than or equal to three times the primary target value.

Step 1: Turn to Example page E11.

Step 2: Now that you have chosen a maximum response time target value for secondary ambulances the distance traveled to reach the "average" citizens must be determined. Ten Tabulation pages (T19 through T28) are provided for the required calculations; one for each subsystem service area. If you have more than ten subsystem service areas, duplicate page T28. If you have fewer than ten subsystem service areas, begin on page T19 and use only those pages that are required for your system. Review Example page E12 before you proceed. Turn to Example page E12.

Step 3: Turn to Guide page G20.

Secondary Response Distance Calculations/District Adjustments

On Tabulation pages T19 through T28, in column six (6) you placed one entry for each response district. This figure represents the miles (air miles) traveled by secondary ambulances to reach the "average" person. On Tabulation page T18, in column seven (7), you calculated the maximum distance acceptable in your system. You must compare all column six (6) entries on Tabulation pages T19 through T28 to the appropriate entry in column seven (7) on Tabulation page T18.* If any of the values in column six (6) (pp. T19-T28) exceed the maximum acceptable values (p. T18) you must redefine your response districts (those with unacceptable distances and the adjacent districts) before proceeding. You may find it necessary to add a response district in some cases.

Step 1: Review your calculated response distances from Tabulation pages T19 to T28 and adjust the districts if necessary. If you add any response districts adjust the entry in column one (1) on Tabulation page T3 accordingly.

Step 2: The only reliable method for evaluating your revised district configuration is to repeat the distance calculation process, but only for districts whose boundaries have been revised. Turn to Tabulation page T19, instruction 1, if revisions are necessary. If not proceed with step 3, below.

Step 3: Turn to Guide page G23, step 3.

* The "appropriate" entry is the entry in column seven (7) on page T18 for the subsystem service area in which the response district in question is located.

Average Distance Conversions

If you are to determine the average response time for each district, to include primary and secondary ambulance response, the maximum distance for primary ambulances must be converted to the average distance that the primary ambulance will travel. On Tabulation pages T4 through T13, in column eight (8) you placed one entry for each response district. This figure represents the miles traveled to reach the "average" person. The average miles traveled equals two-thirds of this distance.

Step 1: a. Multiply each column eight (8) entry on Tabulation pages T4 through T13 by the number "0.67" and enter the result directly below the column eight (8) entry, on the next line.

b. Draw a slash (/) through the column eight (8) entries that you multiplied by "0.67."

c. Proceed to Step 2.

Step 2: Turn to Tabulation page T4, instruction 10.

Step 3: Turn to Guide page G22.

Conversion of Average Distance to Time/District Adjustments

In order to evaluate the average response time of primary and secondary ambulances for each response district, the average distance must be converted to average time. A separate Tabulation page is provided.

Step 1: Turn to Tabulation page T29, instruction 1.

Step 2: On Tabulation page T29, in column four (4) you placed one entry for each response district. This figure represents the average response time to reach the "average" person. On Tabulation page T29, in column five (5), you recorded the maximum response time acceptable in your system. You must compare all column four (4) entries to the appropriate entry in column five (5) on Tabulation page T29. If any of the values in column four (4) exceed the maximum acceptable values you must redefine your response districts (those with unacceptable response time and the adjacent districts) before proceeding. You may find it necessary to add a response district in some cases.

Step 3: If you add any response districts adjust the entry in column one (1) on Tabulation page T3 accordingly.

Step 4: The only reliable method for evaluating your revised district configuration is to repeat the distance calculation process, but only for districts whose boundaries have been revised. Turn to Tabulation page T4, instruction 1, if revisions are necessary. If not proceed with step 5, below.

Step 5: Turn to Guide page G23, step 3.

Demand and Immediate Availability Calculations - Method 1 or 3

System demand, defined as the number of requests for emergency service within a period of time is, for the purposes of this guide, a function of population size. In fact, demand is a function of the socio-economic characteristics of the population, terrain, weather, and several other factors. Computer programs have been developed to simulate demand, but population size provides an adequate estimate for planning purposes.

Since you have chosen a system in which ambulances will be restricted to the district to which they are assigned, each response district must have a sufficient number of vehicles to satisfy the immediate availability criteria.

Step 1: Turn to Tabulation page T14 instructions, instruction 5, and follow the instructions carefully. You are working on Guide page G23.

Step 2: This step must be performed once for each entry in column six (6) on Tabulation page T14. Using the first entry from the column (6), perform the following tasks:

a) On Tabulation page T15, in the column corresponding to the criterion per cent you have chosen (90, 95, or 99) locate the number that equals, or is closest to, but greater than, the entry from column six (6).
b) Read across the chart horizontally to the left margin, column "x".
c) The number in column "x" on Tabulation page T15 is the number of ambulances required in the district corresponding to the entry from column six (6) on Tabulation Page T14.
d) Turn to Tabulation page T3, instruction 3.
e) Repeat steps a-d until all response districts in each subsystem service area have been analyzed, and proceed to step 3.

Step 3: Will your system respond to requests for non-emergency ambulance service?

If your answer is yes, turn to Guide page G24.

If your answer is no, turn to Guide page G25.

Adjustment for Non-emergencies

There are several factors that may influence the impact of non-emergency demand upon an emergency service. You have calculated the required number of emergency vehicles and this number must be increased to maintain an undisturbed level of protection if non-emergency patients are to be transported. The demand (number of non-emergency calls per day) and service time (time required to service the request) must be known. These data should be measured from existing records. By multiplying the service time by the demand the total hours of non-emergency service per day can be determined.

If we assume that all demand will be serviced in an eight hour period the number of vehicles required can be easily determined. Divide the service time (example: 1.5 hours) into eight hours to determine how many requests can be serviced in an eight hour day (example: 5). Divide the daily demand by your answer (example: 20 calls per day divided by 5 calls per ambulance) to determine the number of ambulances required (example: 4). If the number of required ambulances is less than one (1), can the existing system absorb the workload? Yes, but not without reducing the level of protection that the system provides without non-emergencies. A method is available for determining whether your system can absorb any number of non-emergency requests. Assume, for example, that five of your emergency vehicles are to be occupied during the day. Determine which five ambulances will be lost and add the population that they served to ambulances in adjoining districts. Re-calculate the required number of ambulances for the emergency system using increased population figures on Tabulation page T14, or T17.* Although the number of required ambulances may, in theory, not change, response time will certainly change in this system, and some protection will be lost.

If you add ambulances to the system for non-emergency use as well as emergency use, enter the number and district location on Tabulation page T3. Turn to Tabulation page T3, instruction 4, if applicable.

When you complete this section turn to Guide page G25.

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* If you are using Tabulation page T17 perform the calculations as if the population had increased in the subsystem area.

Reducing the Number of Ambulances Required

Much has been said thus far regarding the process for increasing the number of ambulances to an acceptable level, but the data has not been reviewed to determine whether the number of ambulances can be reduced. If the response distances or response times are much smaller than the required minimum, a reduction may be possible.

Step 1: On Guide pages G11, G12, G16, G17, G20, and G22 the procedures for increasing the number of ambulances have been presented. Review these pages, if they are appropriate for your method, and apply the procedures to determine if reductions are possible, by:

a) Examining response distances to identify those that are far smaller than the minimum,
b) Examining response times that can tolerate an increase without exceeding the minimum,
c) Reworking the calculations after eliminating ambulances identified in part "a" or "b" above.

Step 2: If you can reduce the number of ambulances, record the adjustment in column three (3) on Tabulation page T3, and proceed to step 3 below. If not, proceed to step 3.

Step 3: Turn to Guide page G26.

Locating the Ambulance Within the District

Although this guide assumes that each ambulance is located at the center of its district, you may find that, in practice, a "dead" center location is impossible. It should be noted however, that this guide places ambulances where they are needed, whether the location is convenient or not. In most cases a suitable location exists near the center of the response district. A discussion of suitable locations follows.

Fire Stations. There are advantages and disadvantages associated with locating ambulances at fire stations. The most notable advantages are a vehicle/personnel/24 hour oriented facility, a dispatch center, a communications system, and, if operated by a fire department, a source of dedicated, emergency-oriented personnel with supporting administrative and managerial services.

The disadvantages associated with fire station locations relate to the respective missions of the ambulance and fire services. The ambulance is no longer a special form of conveyance--its mission is to deliver the practice of medicine to the field. The fire station is designed to support the delivery of fire combat resources, not medical resources. Therefore, while a fire station does not detract from the ambulance service goals, the advantages associated with a hospital location, for example, are lost. This is not to say that fire service personnel could not be utilized in the system, since they could be stationed at hospitals as easily as any other paramedical personnel (subject to political constraints).

Hospitals. The most notable advantages associated with hospital locations for ambulances are the opportunities provided for skill development through inservice education and the ability to utilize ambulance personnel when the ambulance is idle. The disadvantages may be significant. The hospital may not be located in an appropriate area (whereas fire station locations are usually distributed in a deliberate attempt to reduce response time). In addition, hospitals often provide no facility to house vehicles, and, until recently, rarely utilized radio communication.

Other Locations. Service (gasoline) stations and garages may be considered because of their ability to house vehicles. However neither the advantages of fire stations or hospitals are available. Police department facilities, if properly located, may also be considered. Funeral homes may provide adequate facilities, but the hearse is not usually an acceptable emergency ambulance, and this distinction should be noted if you are planning to utilize funeral homes.

In summary, the vehicles should be placed in the most appropriate facility within the response district, and as close to the center of population as practical. When all ambulances have been located as described on Tabulation page T3 the purpose of this guide has been achieved. A re-evaluation of ambulance location should be performed in the future since demand may, and often does, change with time. The re-evaluation should be conducted with accurate data. A list of the data required is presented on Reference page R7.

Reference Pages

Statewide Area Description

Dividing the State into Regions. For the purposes of this reference Guide the regions to be serviced by ambulance systems may be defined arbitrarily provided they are continuous (see Figure 2). However, there are two considerations which should be taken into account that will greatly reduce the effort required to work through the Guide. The population size in each region is a factor when determining the demand for service and consequently the availability of population data for the area which you define should be considered. SMSA's (Standard Metropolitan Statistical Areas) or Area Planning and Development Commission (APDC) districts should prove to be logical choices from the standpoint of data availability.

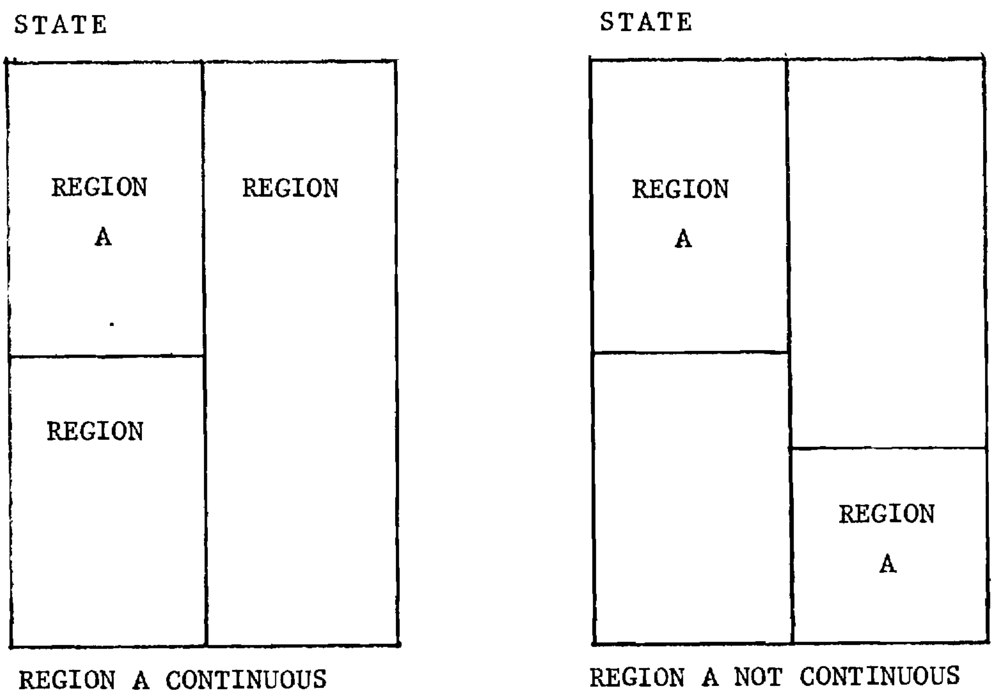

FIGURE 2 Continuous Regions.

A second consideration when defining a region is the effect that your decision will have upon the future management of the ambulance system. Failure to consider the managerial ramifications of your region boundary definitions may precipitate a myriad of problems when the system is implemented. There are several factors that may affect the management of the system, such as telephone exchange boundaries, political boundaries, zip codes, hospital service areas, and health districts, to name a few. Your regions should be defined so as to coincide with or encompass as many subdivisions as possible and practical. In any case, if at all possible, do not create additional subdivisions.* The size of the regions may vary. The upper bound for region size is limited only by the ability of the system administrators to manage it.

Use of the Guide for a Statewide System. The Guide must be applied separately to each region in the State. The regions should be marked on a map and identified with a letter or number code. The Tabulation pages should be reproduced (creating one set for each region), assembled, and set aside for future reference. Turn to Guide page G1, and apply the Guide to the first region (chosen arbitrarily) after you choose a regional system alternative (described on Guide page G1).

* For example, don't define a region so as to bisect a county or city. Include the entire city or county in the region.

Choosing Between a True and Mutual Assistance Regional System

There may be distinct advantages associated with a True Regional System (TRS) as opposed to a Mutual Assistance Regional System (MARS). To illustrate, assume that the region in question contains two counties as shown in Figure 3. Suppose an emergency arises at point "X" and ambulance "AA1" is busy. If the system design is of the MARS variety ambulance "AA2" will be dispatched. "AA2" will take longer to get to point "X" than "BA1" which would be dispatched in a TRS. In addition, both "AA1" and "AA2" would now be busy. County A would require more than two ambulances to maintain the level of protection which would exist if the County B ambulances were routinely available (the TRS alternative).

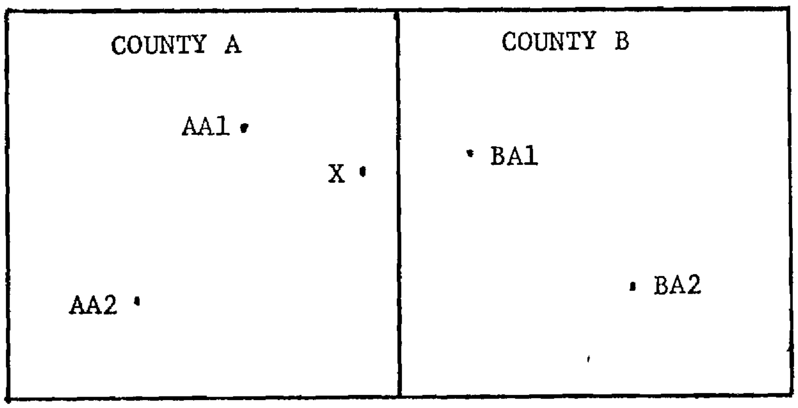

FIGURE 3 A Two County Region.

The annual average operating cost of one ambulance and its personnel will be $70,000 or more (5, p.12). If you wish to compare the cost of a TRS to an MARS work through the guide twice - once using the MARS method and again with the TRS approach. There may be no savings associated with the TRS if the system is very small (1-2 ambulances), but there may be savings if the system is large, and the savings usually increase as the system size increases.

Return to Guide page G1.

Problem Solving Approaches

There are four methods identified on Guide page G3 for solving the ambulance location problem. Each method and the ramifications associated with choosing a particular method are discussed below.

> Method 1: The response time for a primary ambulance will usually not exceed a criterion target value, a primary ambulance will be available immediately for a criterion target per cent of the time, and dependency upon secondary ambulances is minimized.

A primary ambulance is an ambulance that services the district in which it is located while awaiting a call. A secondary ambulance is an ambulance that services a district other than the district in which it is located while awaiting a call.

Application of this method will yield the most expensive system. You must place ambulances throughout the area so that nearly everyone is within a criterion maximum distance from a fixed ambulance location. In addition you must provide enough ambulances at each location to insure that one will be immediately available for some criterion per cent of the time. The cost factor is a distinct disadvantage, and by restricting an ambulance or group of ambulances to one district* you add an element of "waste" to the system. The "waste" is introduced when a district must be assigned an additional ambulance due to the fact that ambulances in the adjoining districts are not to be relied upon for assistance. This second ambulance may rarely be used.

To provide most citizens with an ambulance within a criterion maximum response time, at an acceptable cost, the population density** should be constant throughout the system. If population density is not constant, this method probably should not be used since an average response time would then serve most citizens within a criterion time,

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* The area that can be reached within the criterion response time.

** Number of people per unit of area. For example 100 persons per square mile.

and at a lower cost. There is a distinct advantage to the citizens of a district if the ambulance assigned to that district does not normally leave to pick up patients. In a densely populated area, such as a city, this advantage diminishes. In the urban areas, ambulance districts may overlap, and the larger population may yield a system with extra vehicles, so that ambulances from adjoining districts may be "borrowed" with little risk.

In summary, this method should probably be used in a rural area that has a population that is distributed evenly throughout the area (region, county, city, etc.).

> Method 2: The response time for a primary ambulance will usually not exceed a criterion target value, a primary or secondary ambulance will be available immediately for a criterion per cent of the time, and dependency upon secondary ambulances is not minimized.

As stated above, to provide all citizens with a primary ambulance within a criterion maximum response time, the population should be evenly dispersed throughout the area. By allowing an ambulance to service demand in any district, "waste," as defined on page R3, is eliminated along with the associated costs. However, when an ambulance is used to service a call in an adjoining district, the response time will nearly always exceed the maximum criterion value. The response time can be as much as three times as great as the response time for the primary ambulance, as shown in Figure 4, on the following page.

Does, then, this method have merit (note that Figure 4 portrays the worst case)? If you wish to deal with absolute maximum response time, as opposed to averages, Method 1 or Method 2 must be used, and Method 2 may be less expensive. Since you should attempt to minimize response time, response distance radius "r" should be minimized, and this method would be more appropriately applied to an area with small response districts. Urban areas usually have smaller response districts as well as more ambulances, and the method may be quite acceptable if the population density is constant.

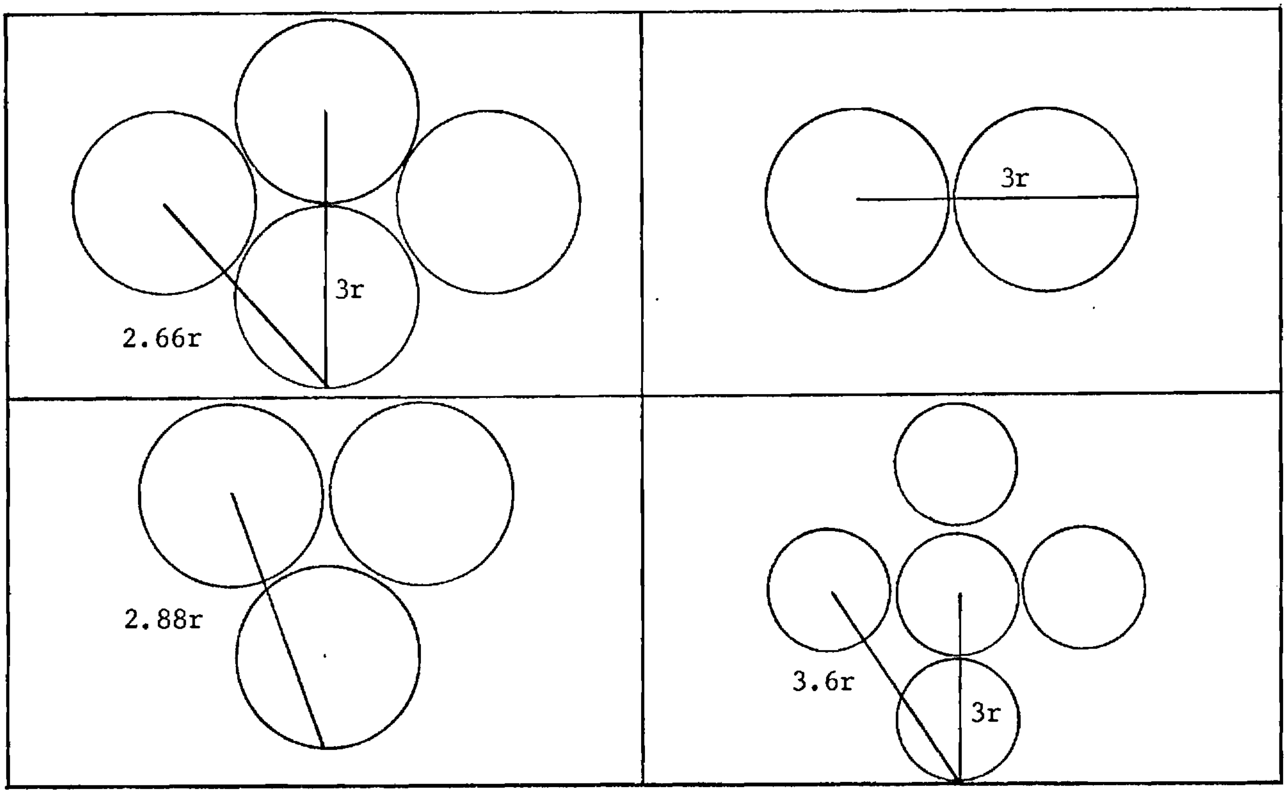

FIGURE 4 Maximum Response Distances.*

Method 3: The response time for a primary ambulance will usually not exceed an average criterion target value, a primary ambulance will be available immediately for a criterion target per cent of the time, and dependency upon secondary ambulances is minimized.

Applicable to areas with variable population density, this method requires fewer ambulances than either of the methods mentioned previously. Sparsely populated areas do not necessarily require an ambulance close by in order to keep the system response time average within reasonable limits. This method places the ambulance(s) in the

* r = radius which is directly proportional to response time.

most densely populated sectors of the subsystem service area. As in Method 1, some waste is incurred by restricting the ambulances to one district. However, the advantage associated with restricting the ambulances to one district may be more significant in this instance. Some citizens may be located much farther from an ambulance than others, and the response time to reach these people from an adjoining district may be prohibitive. This method should probably be used in a rural area that contains some densely populated sub-areas (towns, villages, etc.).

> Method 4: The response time for a primary ambulance will usually not exceed an average criterion target value, a primary or secondary ambulance will be available immediately for a criterion per cent of the time, and depending upon secondary ambulances is not minimized.

This method is the least expensive, has all of the advantages of Method 3, and eliminates "waste." From the preceding discussions it may be deduced that this method is applicable to an urban area that has within it some sectors with a higher population density than others.

Before choosing this method or any of the others you should review a population density map of your area to determine if some combination of methods might be more appropriate. Methods 3 and 4 deal with averages--a potentially deceptive mathematical concept. For example, your system can maintain an average response time of five minutes by serving 95% of the citizens in four minutes and other citizens in 24 minutes. In a life-threatening situation a delay of 24 minutes is worth no more than no ambulance at all!

> Combination of Methods: You may wish to apply more than one method to your area if it contains both a rural and urban area. You may apply more than one method if you identify the sub-areas on a map in such a way that they are continuous (see Figure 2). This Guide should be applied to one sub-area at a time.

Return to Guide page G3, step 2.

Choosing Response Time

Dispatcher Analysis. Response time for your system will directly affect the number of ambulances you will need. As defined in the Guide "Background" section, this quantity describes the length of elapsed time between the receipt of a request for service and the arrival of an ambulance on the scene. Response time is composed of two components: dispatcher analysis (D/A) and ambulance travel time.

Dispatcher analysis (D/A) time can be estimated. The tasks associated with this function are listed below along with estimates of the time each task consumes.

TABLE 2 Dispatcher Analysis Time.

TASK	ESTIMATED TIME (MINUTES)*
Receive Call	-
Record Information	0.78
Locate Emergency on Map	.50
Choose Proper Ambulance	.25
Give Radio/Telephone Dispatch	.65
Total Dispatcher Analysis Time	2.18

Based upon the data presented in Table 2, this guide will utilize an estimate of two (2) minutes for the D/A time. Ambulance travel time is determined by subtracting the D/A time from the response time that you choose.

* Based upon observations of ambulance dispatchers at the Emergency Medical Service of the New York City Health and Hospitals Corporation.

Response Time Estimates. What should the response time be? According to the American Heart Association (AHA), if the patient's heart stops beating (cardiac arrest) at the instant your dispatcher receives the call for help, any response time over six minutes will be unacceptable (3, p.1). In all likelihood the cardiac arrest will occur before you get the call, or after you get the call for help, but not at the exact moment when the call is made. The six minute response time figure, therefore, can not realistically be based exclusively upon this AHA data. The six minute figure is, however, one that you should be familiar with, since after the system is notified, you may wish to guarantee an effective response.

Surveys and observations of successful emergency medical service (EMS) systems produce two estimates for target response times. Four to six minutes seems to be appropriate for urban areas, and up to ten minutes has been cited as appropriate for rural areas.* Many cities with well defined EMS systems utilize police and fire combat vehicles to reach the victim within four minutes if the emergency is reported to be life-threatening. Ambulance response time for one of these systems, Jacksonville, Florida, is 7.4 minutes (average.)**

In summary your response time choice for primary ambulances, if it is to be acceptable by current standards, should fall between four and six minutes for urban areas and should be no larger than ten minutes for rural areas. Average response times, if they reflect the response of secondary ambulances, will usually exceed the maximum response time for primary vehicles by 20 to 30 per cent. When you complete the guide your figures should verify this estimate. If you plan to utilize police and fire resources as initial quick-response vehicles the response time for urban areas may be increased to, perhaps, six to eight minutes.

Return to Guide page G6.

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* Personal correspondence from Eugene L. Nagel, M.D., University of Miami, Department of Anesthesiology, to Oren L. Reinbolt, HSRC dated 27 September 1972.

** Personal correspondence from J. M. Waters, Director, Department of Public Safety, Jacksonville, Florida, to Oren L. Reinbolt, HSRC dated 27 September 1972.

Techniques for Determining Average Speed

Although the variations from the estimated average speed will rarely be of sufficient magnitude to modify the system design, you may wish to measure this quantity in your area. The average speed for an emergency response is calculated by measuring the elapsed time between the time that the ambulance is notified of the emergency and the time that the ambulance arrives at the scene, and dividing this number into the miles traveled to the scene. Measurements may be taken through actual observations by your staff, or may be obtained from ambulance services in your area, provided that the personnel who perform the measurements are properly instructed. If ambulances are not presently available (or reliable) measurements may be made using emergency police vehicles.

How many emergency calls should you measure? The answer to this question is not simple from the statistician's viewpoint. However, repeated samples of ambulance response speeds in the Atlanta area yield very similar results in each case, with large and small samples used. If you have the services of a statistician available you should design your experiment with that person. If not, you might take only a few measurements to verify the estimates presented on Guide page G6. You may measure several responses over a one week period to determine significant differences.

Turn to Tabulation page T1, instruction 8.

Service Time Measurements

Although estimated travel time to the scene, travel time to the hospital, and travel time to return to the ambulance base can be calculated, the estimated time spent at the scene and at the hospital cannot be calculated. Therefore, the only accurate measure of service time, which includes all of the elements mentioned thus far, is achieved through observation. If no ambulance services exist at the present time in your area you cannot locally measure this quantity, and estimates from other systems can be used.

If the opportunity exists, however, you may use a wristwatch, pad, and pencil, accompany a local ambulance service, and record the time required to complete each run. The nature of ambulance demand throughout a geographical area suggests that this method will require extended periods of observation, and delegation of the task will prove to be more practical.

The method is simple. Instruct each ambulance company to record the time that they receive a request for service, and the time that the ambulance is again available to service a call after returning to its base (fixed location). If you are going to provide an emergency care service, but will rely upon another service to transport the victim, you should record (or have the ambulance service record) the time that the request for service is received, and the time that travel to the hospital begins. Unless your response district or service area is very heavily populated, a difference of ten to fifteen minutes either way will not be significant. Therefore, in most cases, only a few observations should be required. The final average service time quantity may be applied to both rural and urban areas, in any case, with a high degree of confidence.

Turn to Guide page G13, step 1.

Data Required for Evaluation and Revision of the Number and Location of Ambulances

Average number of requests for emergency service per district by hour of the day and day of the week.

Average response time per district.

Average response distance per district.

Average number of requests for emergency service per 1000 population per district per day by day of the week.

Average number of runs* exceeding maximum target response time, per district, per day, and associated response time and response distance.

Average utilization (minutes per hour) of each ambulance, by hour of the day and day of the week.

Average number of emergency patients per day arriving at hospital emergency departments, from each subsystem service area, who travel by some means other than emergency ambulance.

Per cent of total runs that were dry runs, per district, where a patient existed and was transported to a hospital although the patient was diagnosed as a non-emergency.

Average service time for dry runs, per district.

Per cent of total runs that were false alarms, per district, where there was no patient, or no patient transported.

Average service time for false alarms, per district.

Per cent, per ambulance, of runs out of the district to which the ambulance is assigned.

Average service time per district, for emergency runs (not including dry runs or false alarms).

It should be noted that many of the performance measures stated above are specific and may be calculated at periodic intervals, perhaps once per month. Furthermore, data need not be routinely collected for all of the aforementioned performance measures, but rather can be collected according to a periodic sampling schedule.

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* Runs: responses to requests.

Choosing a Maximum Target Response Time for Secondary Ambulances

The target response time for secondary ambulances can not be less than the target value for primary ambulances, and you are not required to choose a value greater than three times the primary ambulance target value. As the secondary response target approaches the lower bound (which is the primary response target) the number of acceptable district designs decreases. In addition, the design of an acceptable system configuration becomes more difficult. Your objective is to choose the largest secondary ambulance maximum target response time value acceptable to the population-at-large, medical authorities, or others concerned with system performance. When choosing this target value you should remember that the use of police or fire vehicles in the primary ambulance district can reduce the need for rapid response from a secondary ambulance district. If, for example, police can control hemorrhage and reach the victim as rapidly as a primary ambulance, the arrival of a secondary ambulance twenty minutes later may be of negligible consequence to the victim, since the ambulance may be required to do nothing more than apply bandages in order to relieve the police officer of his immediate first aid responsibility.

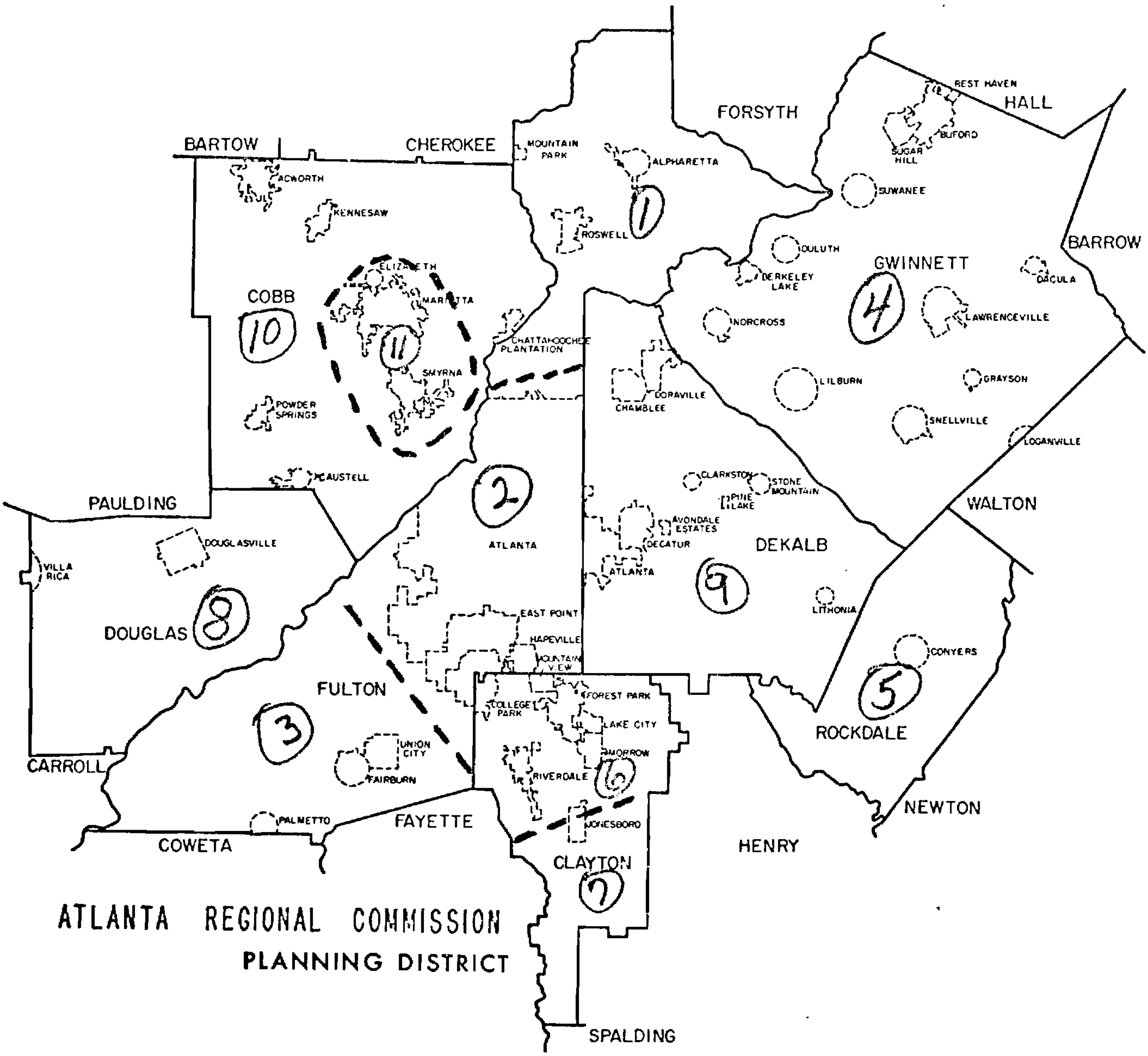
In summary, you must choose a target maximum response time value for ambulances responding to a call outside of their primary district. The target value can not be less than the target value for primary ambulances. You are not required to choose a value greater than three times the primary value. Within this range, your objective is to choose the largest acceptable value. For example, if the target maximum for primary ambulances is six minutes, you must choose the largest acceptable value between six and eighteen minutes.

Turn to Tabulation page T18, instruction 5.

Example Pages

Sample Area Identification

Before proceeding with the tabulation of ambulance requirements review the sample subsystem service area and sub-area (Rural, Urban) identification below.



Turn to Guide page G5, step 3.

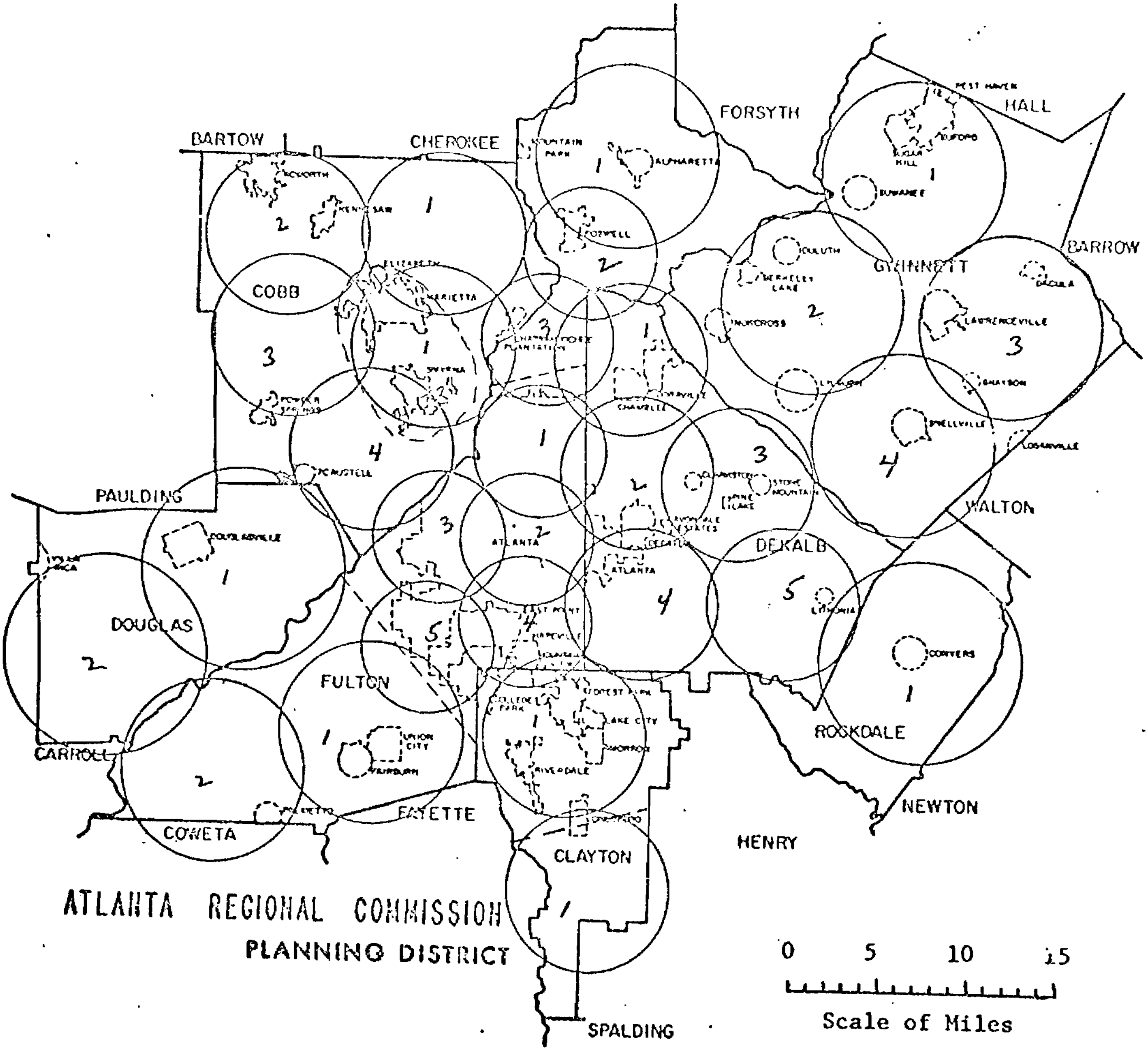
Sample Completed Tabulation Page T1

1	2	3	4	5	6	7
SUBSYSTEM SERVICE AREA OR SUB-AREA	U/R	IDENTIFICATION SYMBOL	RESPONSE TIME (RT)	TRAVEL TIME (RT MINUS 2)	AVERAGE SPEED	RESULT
North Fulton	R	1	8	6	50	4.17
Middle "	U	2	6	4	30	1.67
South "	R	3	8	6	50	4.17
Gwinnett	R	4	8	6	50	4.17
Rockdale	R	5	10	8	55	6.11
Clayton - North	U	6	6	4	30	1.67
" - South	R	7	8	6	45	3.75
Douglas	R	8	10	8	50	5.56
DeKalb	U	9	6	4	35	1.94
Cobb - rural	R	10	8	6	40	3.33
Cobb - urban	U	11	6	4	30	1.67

Turn to Tabulation page T1.

Outlining Response Districts

Below is an example of response district design for a group of seven ambulance subsystem service areas (eleven sub-areas) in a Mutual Assistance Regional System. Note that ambulances will not cross county boundaries. This configuration exemplifies a system designed by Method 1 or 2 (virtually all area is covered).

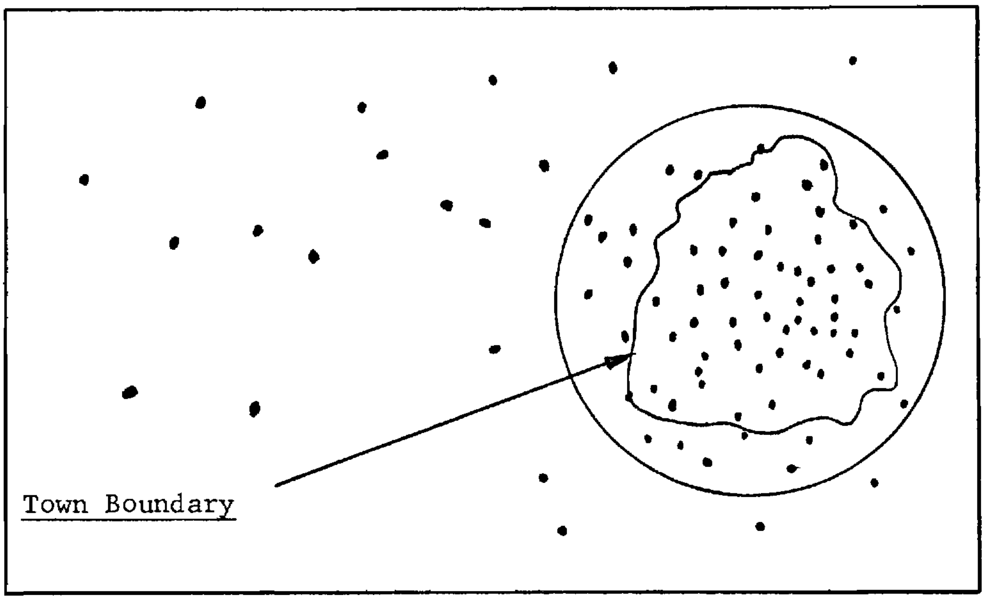


Turn to Example page E4.

Outlining Response Districts

Below is an example of a response district design which exemplifies a system designed by Method 3 or 4 (all population centers are covered).

Service Area (County)



Key: Each "Dot" represents 50 people.

Turn to Guide page G9, step 4.

Sample of Tabulation Page T3

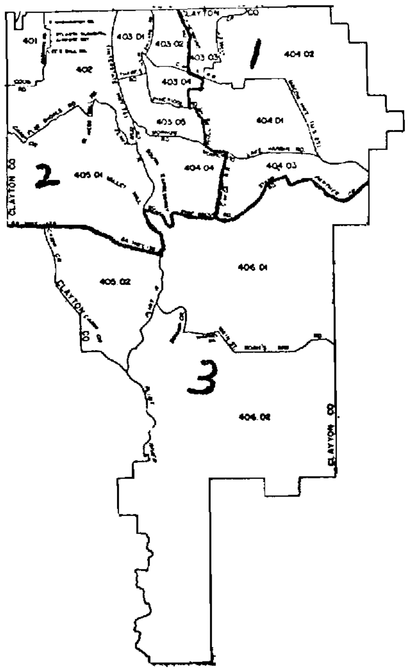
Page 1 of 11

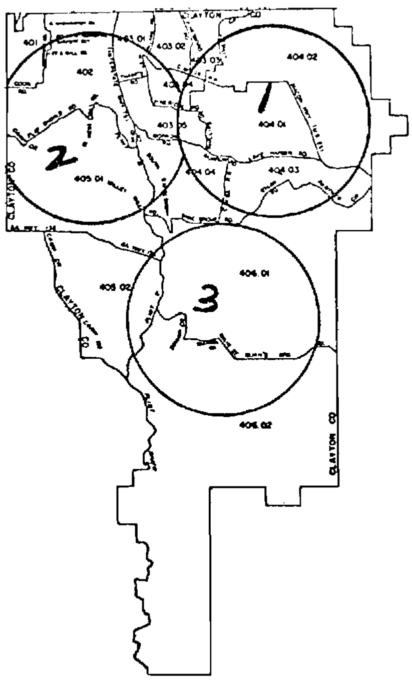
1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL
1-1	1					1
1-2	1				1	0
1-3	1					1
TOTAL	3				1	2

Turn to Tabulation page T3.

Conversion of Response Districts to Census Tracts

Districts from Circles *





Turn to Guide page G10, step 2.

* Note: Service to areas not bound by circles will not meet established criteria. This example illustrates an average response time method; i.e., only population centers are covered.

Sample of Tabulation Page T4

SUBSYSTEM SERVICE AREA: 6 | SUBSYSTEM SERVICE AREA TOTAL: 3.772 | SUBSYSTEM SERVICE AREA RESPONSE TIME: 11.05

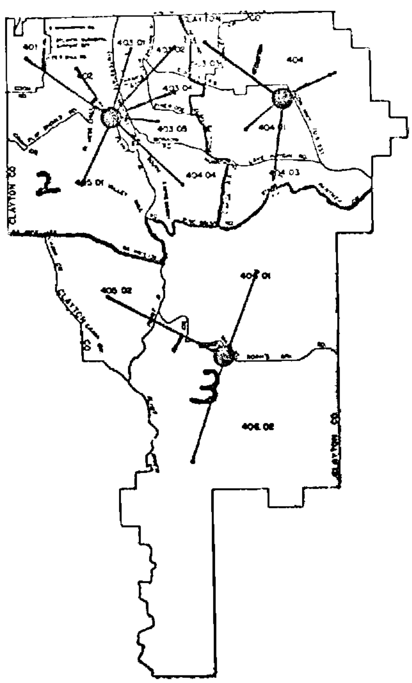
1 RESPONSE DISTRICT	2 CENSUS TRACT NUMBER	3 PER CENT	4 TOTAL POPULATION	5 ACTUAL POPULATION	6 MILES	7 POPULATION MILES	8 AVERAGE MILES/ PERSON	9 PER CENT AVAIL.	10 MILES (OUTSIDE)	11 PER CENT AVAIL. (OUTSIDE)	12 FINAL AVERAGE MILES
1	403.03	100	6963	6963	4.0	27852					
	404.01	100	6969	6969	2.0	13938					
	404.02	100	7385	7385	2.5	18462.5					
	404.03	100	4313	4313	3.3	14232.9					
				25630		74485.4	2.906	0.861	5.812	0.139	3.310 (1.063)
2	401	100	2571	2571	4.4	11312.4					
	402	100	5872	5872	2.5	14680.0					
	403.01	100	2684	2684	3.0	8052.0					
	403.02	100	6956	6956	3.7	25737.2					
	403.04	100	5508	5508	2.8	15422.4					
	403.05	100	6141	6141	1.9	11667.9					
	404.04	100	12678	12678	4.0	50712.0					
	405.01	100	11761	11761	2.9	34106.9					
				54171		171690.8	3.169	0.741	6.338	0.259	3.990 (2.709)
				79801							

Turn to Tabulation page T4.

Centroid Location

Step 1: Review the example.

CENTROIDS



Note: Lines are drawn from ambulance locations to the approximated centroid of each census tract.

Step 2: Complete instruction 6 on Tabulation page T4.

Step 3: Turn to Tabulation page T4, instruction 7.

Example of Tabulation Page T14

1	2	3	4	5	6	7
SUBSYSTEM SERVICE AREA	RESPONSE DISTRICT	POPULATION	X(0.06)	÷ 10,000	1.09	ANSWER 95%
6	1	25630	1537.8	.154	.141	1
	2	54171	3250.26	.325	.298	1

Example of Tabulation Page T17

1	2	3	4	5	6
SUBSYSTEM SERVICE AREA	POPULATION	X(0.06)	÷ 10,000	1.09	ANSWER 95%
1,2,3	607,593	36455.6	3.645	3.344	7
4	72458	4347.5	.435	.399	2
5	18,300	1098	.110	.101	1
6,7	98,043	5882.6	.588	.539	2
8	28,659	1719.5	.172	.158	1
9	415,387	24923.2	2.492	2.286	6
10, 11	185,771	11146.2	1.115	1.023	3

Example of Tabulation Page T18

1	2	3	4	5	6	7
FROM COLUMN (3) PAGE T1	FROM COLUMN (4) PAGE T1	COLUMN (2) TIMES "3"	CHOICE	TRAVEL TIME (RT MINUS 2)	FROM COLUMN (6) PAGE T1	RESULTS
1	8	24	18	16	50	11.1
2	6	18	15	13	30	5.4
3	8	24	18	16	50	11.1
4	8	24	18	16	50	11.1
5	10	30	20	18	55	13.7
6	6	18	15	13	30	5.4
7	8	24	18	16	45	10.0
8	10	30	20	18	50	12.5
9	6	18	15	13	35	6.3
10	8	24	18	16	40	8.8
11	6	18	15	13	30	5.4

Turn to Tabulation page T18, instruction 1.

Example of Tabulation Page T19

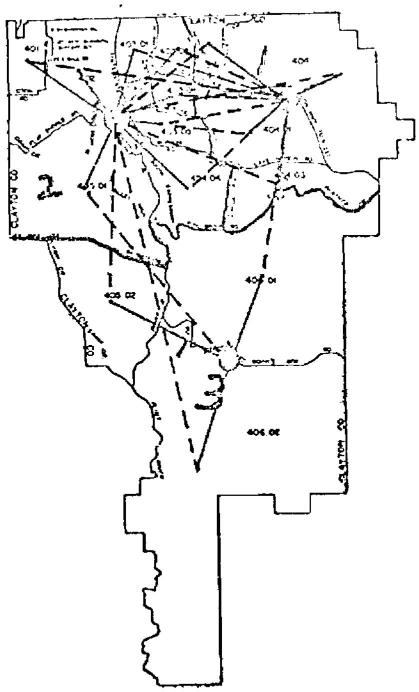
SUBSYSTEM SERVICE AREA: 6

1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON
1	403.03	6963	5.0	34815.0	
	404.01	6969	5.5	38329.5	
	404.02	7385	9.5	70157.5	
	404.03	4313	7.0	30191.0	
		25630		173493.0	6.76
2	401	2571	10.5	26995.5	
	402	5872	8.5	49912.0	
	403.01	2684	6.5	17446.0	
	403.02	6956	5.0	34780.0	
	403.04	5508	4.5	24786.0	
	403.05	6141	5.0	30705.0	
	404.04	12678	5.5	69729.0	
	405.01	11761	9.0	105849.0	
		54171		360202.5	6.64

Turn to Tabulation page T19.

Distance to Closest Secondary Ambulance

Step 1: Review the example.



Key: Dashed lines indicate secondary response distances.

Step 2: Turn to Tabulation page T19, instruction 5.

Tabulation Pages

Instructions for Tabulation Page T1

1. Identify, by name, each subsystem service area or sub-area to complete column one (1).

2. Enter a "U" for an urban area, or "R" for a rural area for the appropriate column one (1) entry, to complete column two (2).

3. Enter each area's identification number in column three (3).

4. Turn to Guide page G5, step 5.

5. In column four (4), enter the target response time that you have chosen for each area.

6. To complete column five (5) enter the travel time by subtracting the number "2" from each entry in column four (4).

7. Turn to Guide page G6, step 2.

8. Enter the determined average speed (for each area) in column six (6).

9. Divide each entry in column six (6) by the number "72", multiply each result by each corresponding entry in column five (5), and enter each final result in the appropriate order, in column seven (7).*

10. Turn to Guide page G6, step 3.

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* The result is a straight line (air mile) distance that can be traveled within a criterion time. The number "72" converts minutes to hours (60) and road miles to air miles (1.2). The road to air miles conversion factor is an estimate, and was obtained from John W. Coyle, Office of Research and Statistics, Social Security Administration.

Instructions on Previous Page

1	2	3	4	5	6	7
SUBSYSTEM SERVICE AREA OR SUB-AREA	U/R	IDENTIFICATION SYMBOL	RESPONSE TIME (RT)	TRAVEL TIME (RT MINUS 2)	AVERAGE SPEED	RESULT

Instructions for Tabulation Page T2

1. In column one (1) enter in order the contents of column three (3) on Tabulation page T1.

2. In column two (2), enter in order the contents of column seven (7) on Tabulation page T1.

3. Multiply each figure in column two (2) by the number (1.5) and enter the result in column three (3).*

4. Turn to Guide page G8, step 1, after you complete the calculations.

* The conversion factor 1.5 is explained in Appendix A.

1	2	3
FROM COLUMN (3) PAGE T1	FROM COLUMN (7) PAGE T1	COLUMN (2) TIMES 1.5

Instructions for Tabulation Page T3

NOTE: Use this page only when referred from the guide.

1. In column one (1) enter an identifying number for each response district in each subsystem service area, as determined from initial estimates on Guide page G9. The first part of the number should identify the subsystem service area. The second part of the number should identify the response district. Refer to Example pages E3 and E5 for assistance. Create a "total" line at the end of the subsystem area and enter the total number of districts in the subsystem service area. You may be adding response districts as you develop the system. Therefore, place only one subsystem service area or sub-area onto a page.

2. After you complete column one (1) turn to Guide page G9, step 7.

3. In column two (2) enter the number of ambulances required in each district as determined from Tabulation page T15, and return to Guide page G23, step 2, part e. Enter the total number of ambulances in each subsystem service area on the "total" line.

4. In column three (3) enter, by district location, the number of ambulances added for non-emergency service.

5. Turn to Guide page G25.

6. In column two (2) on the "total" line enter the number of ambulances required in the subsystem service area as determined from Tabulation page T15, and return to Guide page G15, step 2, part e.

7. In column two (2) enter the number of ambulances in each response district next to the corresponding response district identification number, and return to Guide page G16, step 6.

Page ____ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ___ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ___ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ___ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ____ of _____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ___ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ____ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ____ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ___ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Page ____ of ____

1	2	3	3	3	3	-
DISTRICT NUMBER	REQUIRED AMBULANCES	ADDED	ADDED	ADDED	SUBTRACTED	TOTAL

Instructions for Completing Tabulation Pages T4 through T13

1. Complete the "Subsystem Service Area" heading on each page with the identification symbol for the subsystem service area or sub-area you are analyzing on that page. Calculations for only one subsystem service area or sub-area should be entered on each page. More than one page may be used for each subsystem service area or sub-area. Duplicate tabulation pages if necessary.

2. Beginning on Tabulation page T4 with one subsystem service area or sub-area, in column one (1), enter the number of the first response district (number "1").

3. In column two (2), enter the identification numbers (one to a line) of all census tracts included in this response district (refer to Example page E7 as necessary).

4. In column three (3), enter a figure (estimate) to indicate what per cent of each tract is included in the response district, next to the appropriate tract number (from column two).

5. In column four (4), enter the total population of each tract (even if only a portion of the tract is included), next to the appropriate tract number (from column two).

6. In column six (6), enter the distance in miles from the estimated centroid of each tract, or portion of a tract, to the center of the response district in which it lies, next to the appropriate tract number (from column two). Turn to Example page E8 before proceeding.

7. Skip down two lines (see Example page E7), enter the number of the next response district, and repeat steps 3 through 6 for this response district, until all response districts in the first subsystem service area or sub-area have been examined. When all of these response districts have been examined, turn to Tabulation page T5 and proceed with response districts in the next subsystem service area or sub-area (if applicable).

8. When all subsystem service areas or sub-areas have been examined and columns 1-4 plus column six (6) on all tabulation pages are completed, complete columns five and seven, beginning on Tabulation page T4, by performing the following calculations:

   a. Divide the entry in column three (3) by 100.
   b. Multiply the result of step "a" by the corresponding entry in column four (4).
   c. Enter the result of step "b" in column five (5), for the appropriate census tract.
   d. Multiply the entry in column five (5) by the corresponding entry in column six (6).
   e. Enter the result of step "d" in column seven (7).
   f. When all calculations for the response district have been completed total the figures in column five (5) and place your answer below the last entry for this response district, in column five (5) (see Example page E7 for format).
   g. Repeat step "f" for column seven (7), entering the total below the last entry for this response district, in column seven (7) (see Example page E7 for format).
   h. Divide the total from column seven (7) by the total from column five (5) and enter the result in column eight (8).
   i. Proceed with the calculations for the remaining response districts, beginning with step "a".

9. When all "column eight" calculations are complete turn to Guide page G10, step 4.

10. Column nine (9) is completed in two steps. One entry in column nine (9) is required for each entry in column eight (8). From Tabulation page T3 identify each response district that has more than one (1) ambulance and enter the number "one" (1) in column nine (9) (pages T4-T13) for those districts, on a horizontal line corresponding to the column eight (8) entry.

11. To complete column nine (9) for the remaining response districts, perform the following:

a. Identify the entry from column six on Tabulation page T14 that corresponds to the response district in question.

b. On Tabulation page T16, in any "Y" column, find the number closest to, but greater than if not equal to the entry from column six (6).

c. Read the chart (p. T16) horizontally to the next column "O" on the right.

d. The values that you obtain for the response districts, from column "O", should be entered in column nine (9) on Tabulation pages T4 through T13.

e. Analyze each response district until there is one entry in column nine (9) for every entry in column eight (8), and then proceed with instruction 12.

12. Subtract each entry in column nine (9) from the number "one" and place the result into column eleven (11) on a horizontal line corresponding to the entry in column nine (9) [skip column ten (10)].

13. Multiply each entry in column eight (8) by the number "two" and enter the result into column ten (10) on a horizontal line corresponding to the entry in column nine (9).

14. Multiply each entry in column eight (8) by the corresponding entry in column nine (9), multiply each corresponding entry in column ten (10) by the corresponding entry in column eleven (11), add the two answers together and place your final answer into column twelve (12).

15. Repeat step 14 for each response district.

16. When all calculations for each response district are complete turn to Guide page G21, step 3.

17. Add the totals in column five (5) and enter the total actual population for the area at the bottom of the page, in column five (5).

18. Perform all tasks described in instructions #10 through #15 above. Skip instruction #16. When you complete all calculations for each response district proceed with instruction #19 below.

19. Beginning with the first response district, divide the district population total, from column five (5), by the total population for the area (from the bottom of the page) and multiply the result by the corresponding entry in column twelve (12). Place the result directly under the column twelve (12) entry, in parantheses (see Example page E7 for format).

20. Repeat instruction #19 for each response district, until there are two entries (one in parentheses) in column twelve (12) for each response district.

21. Add the entries in parentheses in column twelve to obtain one final total for each subsystem service area or sub-area. Enter this total from column twelve (12) at the top of the Tabulation page in the space marked "total for subsystem area."

22. Multiply the "total for subsystem service area" by the number "72", divide the answer by the average speed for the subsystem service area (or sub-area), from column six (6), Tabulation page T1, add the number "two" to your answer, and enter the final result into the space "response time for subsystem service area."

23. Turn to Guide page G17, step 3.

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

Tabulation Page T4

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

Tabulation Page T8

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:			SUBSYSTEM SERVICE AREA RESPONSE TIME:				
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

Tabulation Page T10

Tabulation Page T11

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:				SUBSYSTEM SERVICE AREA RESPONSE TIME:			
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

SUBSYSTEM SERVICE AREA:				SUBSYSTEM SERVICE AREA TOTAL:			SUBSYSTEM SERVICE AREA RESPONSE TIME:				
1	2	3	4	5	6	7	8	9	10	11	12
RESPONSE DISTRICT	CENSUS TRACT NUMBER	PER CENT	TOTAL POPULATION	ACTUAL POPULATION	MILES	POPULATION MILES	AVERAGE MILES/ PERSON	PER CENT AVAIL.	MILES (OUTSIDE)	PER CENT AVAIL. (OUTSIDE)	FINAL AVERAGE MILES

Instructions for Tabulation Page T14

1. Record the determined service time here: _______________ minutes.

2. Turn to Guide page G13, step 2.

3. Record the determined criterion per cent (90, 95, or 99), here: ____%

4. Turn to Guide page G14, step 2.

5. Write the "Guide page number" of the page that referred you to this page, in the box in instruction 13. Refer to Example page E9 as necessary as you work through this section.

6. In column one (1) enter the identification symbol for the subsystem service area you are working with (all must be used, one at a time).

7. In column two (2) enter the identification numbers for each response district of the subsystem service area identified in column one (1).

8. In column three (3) enter the population of each response district. Obtain this figure from the population total in the district, which has been identified on Tabulation pages T4-T13, in the "total" lines of column five (5).

9. Multiply each number in column three (3) by the number (0.06) and enter the area products in column four (4).

10. Divide each number in column four (4) by the number (10,000.0) and enter the answers in column five (5).

11. Divide the service time (above) into the number (60) and place your answer into the box at the top of column six (6).

12. Divide each entry in column five (5) by the number you placed into the box at the top of column six (6) and place your answers in column six (6).

13. Turn to page $\boxed{}$, step 2.

1	2	3	4	5	6
SUBSYSTEM SERVICE AREA	RESPONSE DISTRICT	POPULATION	X(0.06)	÷ 10,000	

X	99%	95%	90%
NUMBER OF AMBULANCES	IMMEDIATE AVAILABILITY	IMMEDIATE AVAILABILITY	IMMEDIATE AVAILABILITY
1	.01	.05	.10
2	.14	.35	.53
3	.43	.81	1.1
4	.82	1.4	1.7
5	1.3	2.0	2.4
6	1.8	2.6	3.2
7	2.3	3.3	3.9
8	2.9	4.0	4.7
9	3.5	4.7	5.4
10	4.1	5.4	6.2
11	4.8	6.2	7.0
12	5.4	6.9	7.8
13	6.1	7.7	8.6
14	6.8	8.5	9.5
15	7.5	9.2	10.3
16	8.2	10.0	11.1
17	8.9	10.8	12.0
18	9.6	11.6	12.8
19	10.3	12.4	13.7
20	11.1	13.2	14.5
21	11.8	14.1	15.3
22	12.6	14.9	16.2
23	13.3	15.7	17.1
24	14.1	16.5	18.0
25	14.8	17.3	18.8
26	15.6	18.2	19.7
27	16.4	19.0	20.6
28	17.1	19.9	21.4
29	18.0	20.7	22.3
30	18.7	21.6	23.2
31	19.5	22.4	24.1

Y	0	Y	0
0.01	0.990	0.60	0.549
0.02	0.980	0.65	0.522
0.03	0.970	0.70	0.497
0.04	0.961	0.75	0.472
0.05	0.951	0.80	0.449
0.06	0.942	0.85	0.427
0.07	0.932	0.90	0.407
0.08	0.923	0.95	0.387
0.09	0.914	1.00	0.368
0.10	0.905	1.1	0.333
0.15	0.861	1.2	0.301
0.20	0.819	1.3	0.273
0.25	0.779	1.4	0.247
0.30	0.741	1.5	0.223
0.35	0.705	1.6	0.202
0.40	0.670	1.7	0.183
0.45	0.638	1.8	0.165
0.50	0.607	1.9	0.150
0.55	0.577	2.0	0.135

Instructions for Tabulation Page T17

1. Write the "Guide page number" of the page that referred you to this page, in the box in instruction 8. Refer to Example page E10 as necessary as you work through this section.

2. In column one (1) enter the identification symbol for each subsystem service area.*

3. In column two (2) enter the population of each subsystem service area next to the corresponding number from column one (1).

4. Multiply each number in column two (2) by the number (0.06) and enter the area products in column three (3).**

5. Divide each number in column three (3) by the number (10,000.0) and enter the answers in column four (4).**

6. Divide the service time (from Instruction 1, Tabulation page T14) into the number (60) and place your answer into the box at the top of column five (5).

7. Divide each entry in column four (4) by the number you placed into the box at the top of column five (5) and place your answers in column five (5).

8. Turn to page [,] Step 2.

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* Do not identify sub-areas. As defined on Guide page G1 the subsystem service areas may be counties, cities, or other subdivisions to which the ambulances are assigned.

** Conversion factors convert population to ambulance calls per hour as described in Appendix D.

1	2	3	4	5
SUBSYSTEM SERVICE AREA	POPULATION	X(0.06)	÷ 10,000	

Instructions for Tabulation Page T18

1. In column one (1) copy, in order, the contents of column three (3) from Tabulation page T1.

2. In column two (2) copy, in order, the contents of column four (4) from Tabulation page T1.

3. Multiply each entry in column two (2) by the number "3" and enter the product in column three (3).

4. Turn to Reference page R8.

5. For each subsystem service area or sub-area choose a target maximum response time for secondary ambulances that is greater than or equal to the entry in column two (2) and less than the entry in column three (3). Enter your choice for each area into column four (4).

6. To complete column five (5) enter the travel time by subtracting the number "2" from each entry in column four (4).

7. In column six (6) copy, in order, the contents of column six (6) from Tabulation page T1.

8. Divide each entry in column six (6) by the number "72", multiply each result by the corresponding entry in column five (5), and enter each final result in the appropriate order, in column seven (7).

9. Turn to Guide page G19, step 2.

1	2	3	4	5	6	7
FROM COLUMN (3) PAGE T1	FROM COLUMN (4) PAGE T1	COLUMN (2) TIMES "3"	CHOICE	TRAVEL TIME (RT MINUS 2)	FROM COLUMN (6) PAGE T1	RESULTS

Instructions for Tabulation Page T19

1. Complete the "Subsystem Service Area" heading on each page with the identification symbol for the subsystem service area or sub-area you are analyzing on that page. Calculations for only one subsystem service area should be entered on each page. More than one page may be used for each subsystem service area. Duplicate tabulation pages if necessary.

2. Beginning on Tabulation page T19 with one subsystem service area, in column one (1), enter the number of the first response district (Number "1").

3. In column two (2) enter the identification numbers (one to a line) of all census tracts included in this response district. You may obtain this data from column two (2) on the appropriate* Tabulation page T4 through T13.

4. In column three (3) enter, in order, the contents of column five (5) (including "Total") from the appropriate Tabulation page T4 through T13.

5. In column four (4) enter (for each tract) the distance in miles from the estimated centroid of the tract, or portion of a tract, to the center of the response district of the closest <u>secondary ambulance</u>. Turn to Example page E13 before proceeding.

6. Skip two lines, enter the number of the next response district, and repeat steps 3 through 6 for this response district. Continue until all districts in the first subsystem service area have been examined. When all of these response districts have been examined, turn to Tabulation page T20 and proceed with response districts in the next subsystem service area (if applicable).

7. When all subsystem service areas have been examined and columns 1-4 on all tabulation pages are completed, complete columns five

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* The "appropriate" page corresponds to the subsystem service area with which you are working.

and six, beginning on Tabulation page T19, by performing the following calculations:

a. Multiply each entry in column four (4) by the corresponding entry in column three (3).

b. Enter each result from step "a" into column five (5), next to the corresponding entry in column four (4).

c. When all calculations for the response district have been completed total the figures in column five (5) and place your answer below the last entry for this response district, in column five (5) (see Example page E12 for format).

d. Divide the total from column five (5) by the total from column three (3), and enter the result in column six (6).

e. Proceed with the calculations for the remaining response districts, beginning with step "a".

8. When all "column six" calculations are complete turn to Guide page G19, step 3.

SUBSYSTEM SERVICE AREA:					
1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:					
1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:					
1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:

1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:

1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:

1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:					
1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:					
1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:

1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

SUBSYSTEM SERVICE AREA:

1	2	3	4	5	6
RESPONSE DISTRICT	CENSUS TRACT NUMBER	ACTUAL POPULATION	MILES	POPULATION MILES	MILES/ AVERAGE PERSON

Instructions for Tabulation Page T29

1. In column one (1) copy, in order, the contents of column one (1) from all Tabulation pages T3. You are not required to place each subsystem service area on a separate page. Five pages T29 are provided. If necessary, duplicate to produce additional tabulation space.

2. In column two (2) enter the appropriate average speed for ambulances in each response district, as described in column six (6) on Tabulation page T1.

3. In column five (5) enter the appropriate response time target for each response district, as described in column four (4) on Tabulation page T1.

4. In column three (3) enter the mileage for each response district, as described in column twelve (12) on Tabulation pages T4-T13.

5. Multiply the first entry in column three (3) by the number "72", divide the result by the corresponding entry in column two (2), add the number "2" to your answer, and enter the final result into column four (4).

6. Turn to Guide page G22, step 2.

Page __ of __

1	2	3	4	5
FROM COLUMN (1) PAGE T3	FROM COLUMN (6) PAGE T1	AVERAGE MILES (T4-T13)	RESULT	TARGET TIME

Page __ of __

1	2	3	4	5
FROM COLUMN (1) PAGE T3	FROM COLUMN (6) PAGE T1	AVERAGE MILES (T4-T13)	RESULT	TARGET TIME

Page __ of __

1	2	3	4	5
FROM COLUMN (1) PAGE T3	FROM COLUMN (6) PAGE T1	AVERAGE MILES (T4-T13)	RESULT	TARGET TIME

Page __ of __

1	2	3	4	5
FROM COLUMN (1) PAGE T3	FROM COLUMN (6) PAGE T1	AVERAGE MILES (T4-T13)	RESULT	TARGET TIME

Page __ of __

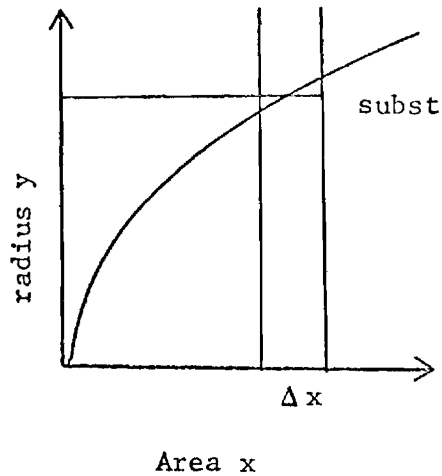
1	2	3	4	5
FROM COLUMN (1) PAGE T3	FROM COLUMN (6) PAGE T1	AVERAGE MILES (T4-T13)	RESULT	TARGET TIME

APPENDICES

Appendix A: Calculation of Radius (R) Guaranteeing an Average Response Distance of r Miles

This appendix is developed to enable an analyst to determine the average response time of an ambulance with a circular service area concentric with the ambulance headquarters, based strictly upon expected ambulance travel speed. Since response time is directly proportional to road distance, which in turn is proportional to air distance, the size of a circle (air distance) may be calculated for any given criterion response time. The size of the criterion response time circle is important in the technique of graphically approximating the number and location of ambulances required to guarantee criterion response time in a service area.

Rectangular coordinate system:



area = $\pi(\text{radius})^2$

substituting, $x = \pi(y)^2 \Longrightarrow y = \left(\frac{x}{\pi}\right)^{\frac{1}{2}}$

Assuming:

1) population density is uniform within the circle prescribed by the radius to be calculated and = $P \frac{\text{people}}{\text{unit area}}$

2) road distance (r_r) is directly proportional to air distance (r) by a factor (α) such that $r_r = \alpha r$

3) ambulance is located at origin of circle, will travel a maximum air distance of R

average air distance per person is given by:

$$\frac{\sum_{\text{all people}} (\text{person}) \times (\text{air distance from ambulance})}{\text{total people}} = r_{ave}$$

symbolically:

$$r_{ave} = \frac{\int_0^{\bar{A}} p \left(\frac{x}{\pi}\right)^{\frac{1}{2}} dx}{P \cdot \pi R^2} \qquad \text{where } \bar{A} = \text{total area} = \pi R^2$$

Integrating over the total area,

$$r_{ave} = \frac{P\pi^{-\frac{1}{2}} \int_0^{\pi R^2} x^{\frac{1}{2}} dx}{P\pi R^2} = \frac{P(\pi)^{-\frac{1}{2}} \cdot \frac{2}{3} (\pi)^{\frac{3}{2}} R^3}{P\pi R^2} = \frac{P\pi R^2 \cdot \frac{2}{3} R}{P\pi R^2}$$

$$= \frac{2}{3} R \implies r_{ave} = \frac{2}{3} R$$

$$\implies \Gamma r_{ave} = \frac{2R\alpha}{3}$$

Thus, the average air distance travelled by the ambulance (r_{ave}) is seen to equal two-thirds of the maximum air distance travelled. The average road distance (Γr_{ave}) equals the average air distance multiplied by the factor α (to give $\frac{2}{3} R\alpha$).

Appendix B: Expected Demand to be Placed Upon an Emergency Medical System

The number of requests for emergency medical service to be expected in an operating EMS system directly affects the design of the system in terms of number and location of vehicles, size of the dispatch center, and many other elements of the system. Due to the inadequacy of present ambulance records in many localities, a good methodology for determining the number of calls expected to be generated for EMS simply does not exist. Therefore, the estimates of demand for EMS must be based upon known factors, in this case population. Several formulas have been devised in other reports to predict demand for EMS as a function of population. These formulas are analyzed and compared to estimates and rough data to determine which formula best suits the individual system.

The Dunlap Report, "Economics of Highway Emergency Ambulance Services," (2) includes a graph of the annual number of emergency calls generated from populations of service areas. The purpose of the graph is to allow an analyst to predict demand placed upon an EMS system as a function of population only, keeping in mind the fact that population figures are generally easily obtainable whereas ambulance records are not. Based upon the responses of 80 ambulance purveyors to the question "Approximate number of emergency ambulance calls per year?", the report concluded that a good estimate of the number of emergency ambulance calls generated may be calculated by the formula:

$$Y = 10.06X + 70$$

where Y is the number of emergency calls/yr.
X is the population of the service area divided by 1000

For the city of Houston, Texas, then, the formula would predict:

$$Y = (10.06) \cdot (1233) + 70 = 12{,}473 \text{ emergencies/yr.}$$

However, records of emergency runs in Houston show that the ambulances were called upon to answer 47,100 emergency runs last year. Table 3 shows the actual and predicted demand for emergency service for two large southern cities and a northern city. In each case, the Dunlap prediction falls short of the actual demand by at least 300%.

TABLE 3 Actual and Predicted Demand for EMS in Three Cities.

CITY	POPULATION	CALLS ACTUALLY RECEIVED	PREDICTED BY DUNLAP FORMULA	PREDICTED BY "35 PER YEAR PER 1000 POPULATION"
Jacksonville	529,000	19,300*	5,391	18,515
Houston	1,233,000	47,100**	12,473	43,155
Columbus, Ohio	600,000	25,226***	6,106	21,000

Captain Waters of Jacksonville, Florida, has stated that demand upon an EMS system is generated at the rate of one call per day per 10,000 population or 36.5 patients per 1000 population per year. Other cities with operating EMS systems have been analyzed (4) and found to generate calls on the average of 35 patients per 1000 population per year. (The Stevenson Estimate)

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* Personal interview with Captain John Waters on December 8, 1972.

** Personal correspondence with Captain Martin on September 29, 1972.

*** Personal interview with Chief Werner on September 5, 1972.

Appendix C: A Queuing Formula to Determine Percentage of Immediate Availability of Ambulances, Given Total Number of Ambulances in the System

This appendix provides a mathematical model based upon the theory of queues (waiting lines) to determine the probability of a patient who needs an ambulance, finding that all ambulances are busy, given the number of ambulances in the system. The analysis shows that the probability of any given number of ambulances being busy at any given instant in time is dependent upon the arrival rate of calls (μ) and closely approximates the common Poisson probability distribution which means (λ/μ). From the probability of various numbers of ambulances being occupied at a given instant in time, the probability of finding that all ambulances are busy can be inferred, given the total number of ambulances.

Let: s = total number of ambulances in the system
n = number of busy ambulances at any given time
λ_n = arrival rate of calls for service, given n busy ambulances
μ_n = service rate by n ambulances working together
P_n = probability of n ambulances being busy at one time

Assume: 1) Poisson Arrival of demand for ambulance service
2) Exponential Service Times for ambulance calls
3) $\lambda_n = \lambda$ for all $n>0$
4) $\mu_n = n\mu$ for $0 \leq n \leq s$

The single-server, steady-state solution for exponential service and Poisson arrivals is well known and cited in most operations research texts to be:

$$P_n = \frac{\prod_{i=0}^{n-1} \lambda_i}{\prod_{i=1}^{n} \mu_i} \cdot P_0 \quad \text{, for } n \geq 1$$

$$\sum_{n=0}^{\infty} P_n = 1 \Rightarrow P_0 + \frac{\lambda_0}{\mu_1} P_0 + \frac{\lambda_0 \lambda_1}{\mu_1 \mu_2} P_0 + \ldots = 1$$

or,

$$P_0 \left[1 + \sum_{n=0}^{\infty} \frac{\prod_{\iota=0}^{n-1} \lambda_\iota}{\prod_{\iota=1}^{n} \mu_\iota} \right] = 1$$

thus,

$$P_o = \frac{1}{1 + \sum_{n=0}^{\infty} \frac{\prod_{\iota=0}^{n-1} \lambda_\iota}{\prod_{\iota=1}^{n} \mu_\iota}}$$

Extending this result to the multiple server case:

$$P_n = \frac{\prod_{\iota=0}^{n-1} \lambda_\iota}{\prod_{\iota=1}^{n} \mu_\iota} P_o$$

as before, but $\lambda_\iota = \lambda$ for all ι
and $\mu_n = n\mu$ for $0 \leq \mu \leq s$

thus,

$$P_n = \frac{\lambda^n}{\mu \cdot 2\mu \cdot 3\mu \ldots} \cdot P_o = (\frac{\lambda}{\mu})^n \cdot \frac{P_o}{n!} \quad \text{for } n \leq s$$

making the approximation that s is large, n is expected to always be less than s, and the above term for p_n is accurate.

To find P_o, use the fact that $\sum_{n=0}^{s} P_n \doteq 1$

letting $\rho = \frac{\lambda}{\mu}$, $P_o \left[1 + \frac{\rho}{1!} + \frac{\rho^2}{2!} + \frac{\rho^3}{3!} + \ldots + \frac{\rho^s}{s!} \right] \doteq 1$

$$= P_o \left[\sum_{k=0}^{s} \frac{\rho^k}{k!} \right] \doteq 1 \quad , \text{for } \frac{\rho}{s} < 1$$

therefore, $$P_o = \frac{1}{\sum_{k=0}^{s} \frac{\rho^k}{k!}}$$

and,

$$P_n = \frac{\rho^n}{n!}(P_o) \implies P_n = \left(\frac{\rho^n}{n!}\right) \frac{1}{\sum_{k=0}^{s} \frac{\rho^k}{k!}}$$

or,

$$P_n = \frac{\frac{(\lambda/\mu)^n}{n!}}{\sum_{k=o}^{s} \frac{(\lambda/\mu)^n}{k!}}$$

The values for P_n calculated above closely approximate the Poisson probability function as long as s is large relative to (λ/μ). In effect, when the percent of immediate availability of ambulances is large, the number of busy ambulances in the system closely approximates a Poisson distribution with mean (λ/μ).

A numerical example follows in Table 4:

if $s = 5$ ambulances
$\lambda = 1$ call/hour
$\mu = 1$ call/hour
then $\lambda/\mu = 1/1 = 1$

TABLE 4 Numerical Example of Immediate Availability Calculations.

n	$(\lambda/\mu)^n$	n!	$\frac{(\lambda/\mu)^n}{n!}$	P_n	$\sum_{\ell=0}^{n} P_\ell$	Poisson Cumulative Probability $[\lambda=1]$
0	1	1	1	.3681	.368	.368
1	1	1	1	.3681	.736	.736
2	1	2	0.5	.1840	.920	.920
3	1	6	0.166	.0614	.982	.981
4	1	24	0.042	.0153	.997	.996
5	1	120	0.008	.0031	1.000	.999
			$\sum=2.716$	$\sum=1.0000$		

The example shows the last two columns nearly identical, illustrating the fact that the Poisson probability function describes the number of busy ambulances in the system.

Appendix D: Number of Ambulances Required to Satisfy the Availability Criterion

The solution to the ambulance number and location problem can be greatly simplified through an application of the mathematical theory of queues. In order to apply the technique and, subsequently, data obtained from the common Poisson probability distribution, certain crucial assumptions must be made. This appendix describes the assumptions and the method upon which immediate availability calculations in the present Guide are based.

To determine the number of ambulances required to guarantee an immediate availability of some criterion level, the mathematical theory of waiting lines (queues) is used. Empirical evidence suggests that calls for emergency medical service arrive randomly, totally independent of each other.*

Cases arise where calls are not generated at random, such as fires, floods, and multiple victim accidents, but these occurrences occur infrequently and are therefore treated as disaster situations.

A general mathematical theory of the performance of waiting lines is available and may be applied using the following assumptions.

1) Calls for emergency service arrive randomly with a known average number per hour, which may vary with the time of day or day of week.
2) All ambulances are identical in capability and a total of N ambulances exist. No back-up service exists.
3) The average service time for emergency ambulance calls is known.
4) Calls received when all N ambulances are busy will form a waiting line and be served on a first-come, first-served basis.
5) Ambulances can not desert one call for another.

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* The same mathematical theory describes the arrival rate of telephone calls to a telephone operator at a switchboard, from which early waiting line theory was developed. This parallel may appeal to the intuition of the reader.

The assumptions become less binding as the number (N) of ambulances in the system increases. To guarantee a high percentage of immediate availability, N must be chosen large enough for a waiting line to form only rarely, and a good approximation is to let N approach infinity. As N grows large, an ambulance is never required to desert one call for another call, since a second ambulance is dispatched instead. No back-up service is ever utilized, therefore no back-up service needs to exist. The order in which waiting calls are served (queueing discipline) is not important to the solution process since calls are assumed to never wait for service, that is, an ambulance is always available. Thus, it can be seen that the assumptions become increasingly valid as the immediate availability (or the total number) of ambulances in the system increases.

Therefore, if the arrival rate of calls for EMS and the service times for ambulance runs are specified, the probability of any arbitrary number of ambulances being busy is easily read from probability tables as shown in Appendix C.

The arrival rate of calls for emergency service depends on diverse characteristics of the population being served but has been found to grossly increase proportionately with the size of the population. Naturally, call frequency can best be determined from past records of ambulance services, but the records are often incomplete, difficult to access, very time consuming to review, and often contain grouped data which can cause misleading statistics. For example, few ambulance services separate emergency runs from non-emergency transfers in the ambulance records.

An estimate of 35 emergency calls per 1000 population per year in the ambulance service area is therefore used as an estimate of average demand to be placed upon the EMS system.* To determine the peak load placed on the EMS system by daily cycles of demand, the estimate is made that peak demand is 150 per cent of average demand. Data from Grady Ambulance Service (Atlanta) and from the EMS system in Cambridge, Massachusetts support this estimate.

The time required per ambulance run is also based upon estimates, rather than records. Once again, the records of many ambulance services

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* Appendix B gives a justification for the estimate.

do not contain the information necessary to generate reliable statistics. Most ambulance operators questioned through various surveys responded that average service time falls between 30 minutes and one hour. A conservative estimate for average service time can therefore be taken as one hour.

Keeping the previous discussions in mind, the number of ambulances required to guarantee 90 per cent immediate availability for a sample EMS system can be calculated. Example County is taken as an example:

1) Example County Population = 98,043

2) $\dfrac{98043 \text{ persons}}{1} \times \dfrac{35 \text{ emergency calls}}{1000 \text{ pop/yr}} = 3431 \text{ calls/year}$

3) $\dfrac{3431 \text{ calls}}{\text{year}} \times \dfrac{1 \text{ year}}{365 \text{ days}} \times \dfrac{1 \text{ day}}{24 \text{ hours}} = 0.392 \text{ calls/hour}$

Example County is expected, therefore, to generate 0.392 calls for EMS per hour on the average. Since peak demand is 150 per cent of average demand:

4) $0.392 \times 1.50 = 0.587$ calls/hour = peak demand

The following table can be constructed using waiting line theory from the previous assumptions regarding emergency call arrival rate and ambulance service times in Example County.

TABLE 5 Per Cent of Time that Various Numbers of Ambulances in Example County are Occupied at any Given Instant.

NUMBER OF BUSY AMBULANCES	EXPECTED PER CENT OF TIME	CUMULATIVE (PER CENT)*
no busy ambulances	54.7	54.7
exactly one busy ambulance	32.9	87.6
exactly two busy ambulances	9.9	97.5
exactly three busy ambulances	2.0	99.5
exactly four busy ambulances	0.3	99.8
exactly five busy ambulances	0.1	99.9

From Table 5, it can be seen that two or less ambulances are expected to be busy 97.5 per cent of the time. Therefore, if Example County has three ambulances, the chances (or probability) of one ambulance being available when called is 97.5 per cent.

* Figures presented in this column represent a running sum of the percentages in the middle column.

Appendix E: Requirements for Final Assembly of the Guide

This appendix describes a method for re-assembling the present report to minimize distractions and to facilitate its use. Although there may be useful alternatives, the method proposed here has been tested and found acceptable.

The Guide in its final form includes five discrete subsections which are described in Table 6.

TABLE 6 Contents of the Guide.

Subsection Description	Includes
-- Introductory Pages	The Foreword and Introduction of the present report, Pages ii, iii, 1, 2 and 3.
-- Programmed Guide Pages G1 through G26.	Pages 4 through 33 of the present report.
-- Reference Subsection.	The Reference Pages (R1 - R8), Appendices (A-E) and References; Pages 34 through 46, and pages 115 through 133 of the present report.
-- Tabulation Pages T1 through T21.	Pages 60 through 114 of the present report.
-- Example Pages E1 through E13.	Pages 47 through 59 of the present report.

The use of the Guide will vary according to the method chosen by the user. However, some generalities apply. The user should read the Foreword, Introduction, Instructions to the User, and Guide page G1 in that order. The Guide pages control the sequence to be followed, and may refer the user to Reference, Example, or Tabulation pages. Example pages refer the user to Tabulation pages. Tabulation pages refer to Example pages, and return the user to the Guide pages. Reference pages may refer the user to any of the aforementioned subsections.

The user of the Guide is always referred to Tabulation page instructions which subsequently refer to tabulation space. The user will be required to refer back to Tabulation page instructions often.

The final product should be assembled as shown in Figure 5. The title page of this report (page i) should be placed in front of the Foreword. Details are illustrated in Figures 6 and 7. Appendices, located behind the Reference page subsection, are not included in the Guide program and, therefore, not indexed with a separate index tab. Numbers appearing at the bottom of each page in this report should be removed before the Guide is assembled. Alpha-numeric pagination at the top of each programmed page should remain.

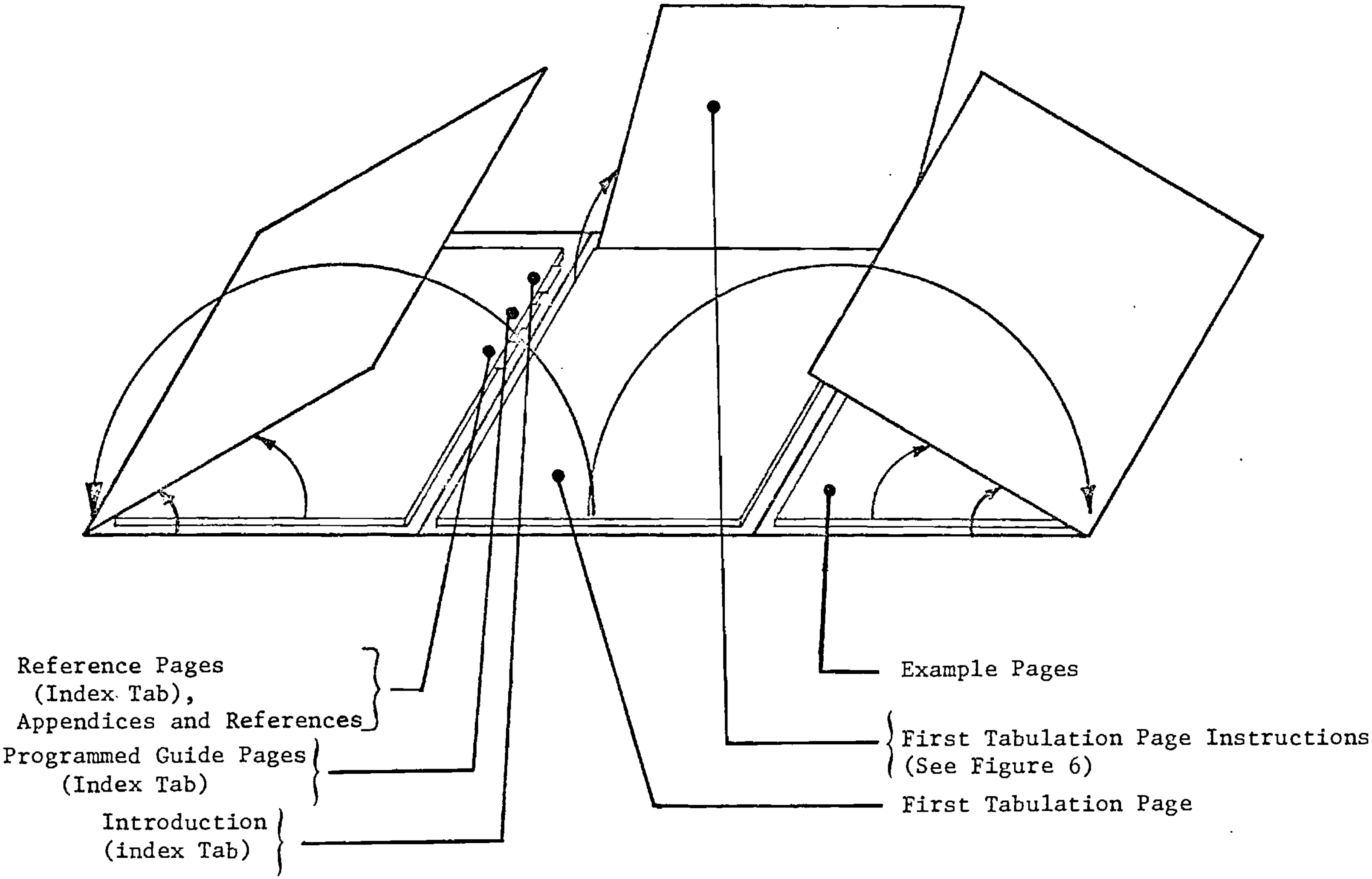

FIGURE 5 Entire Guide Package.

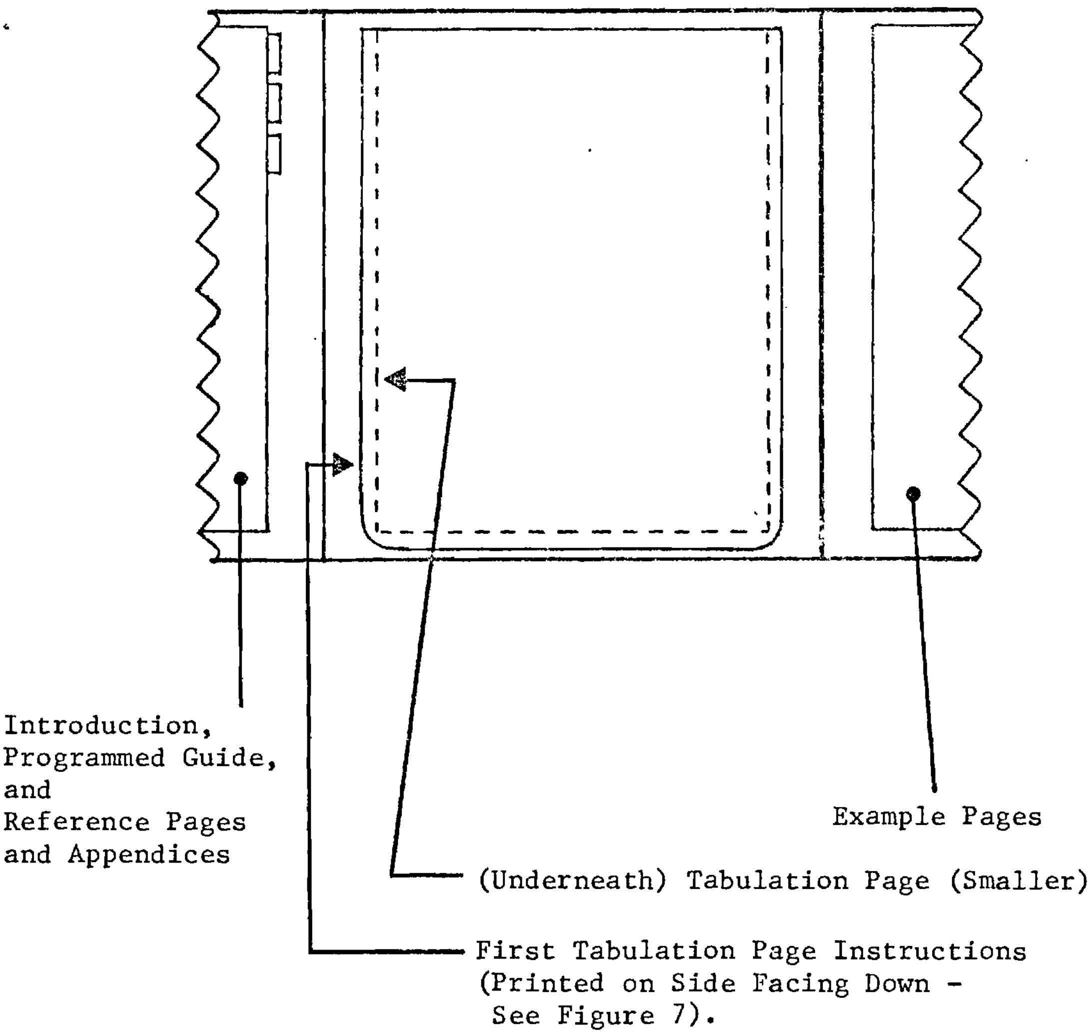

FIGURE 6 Top View of Tabulation Subsection.

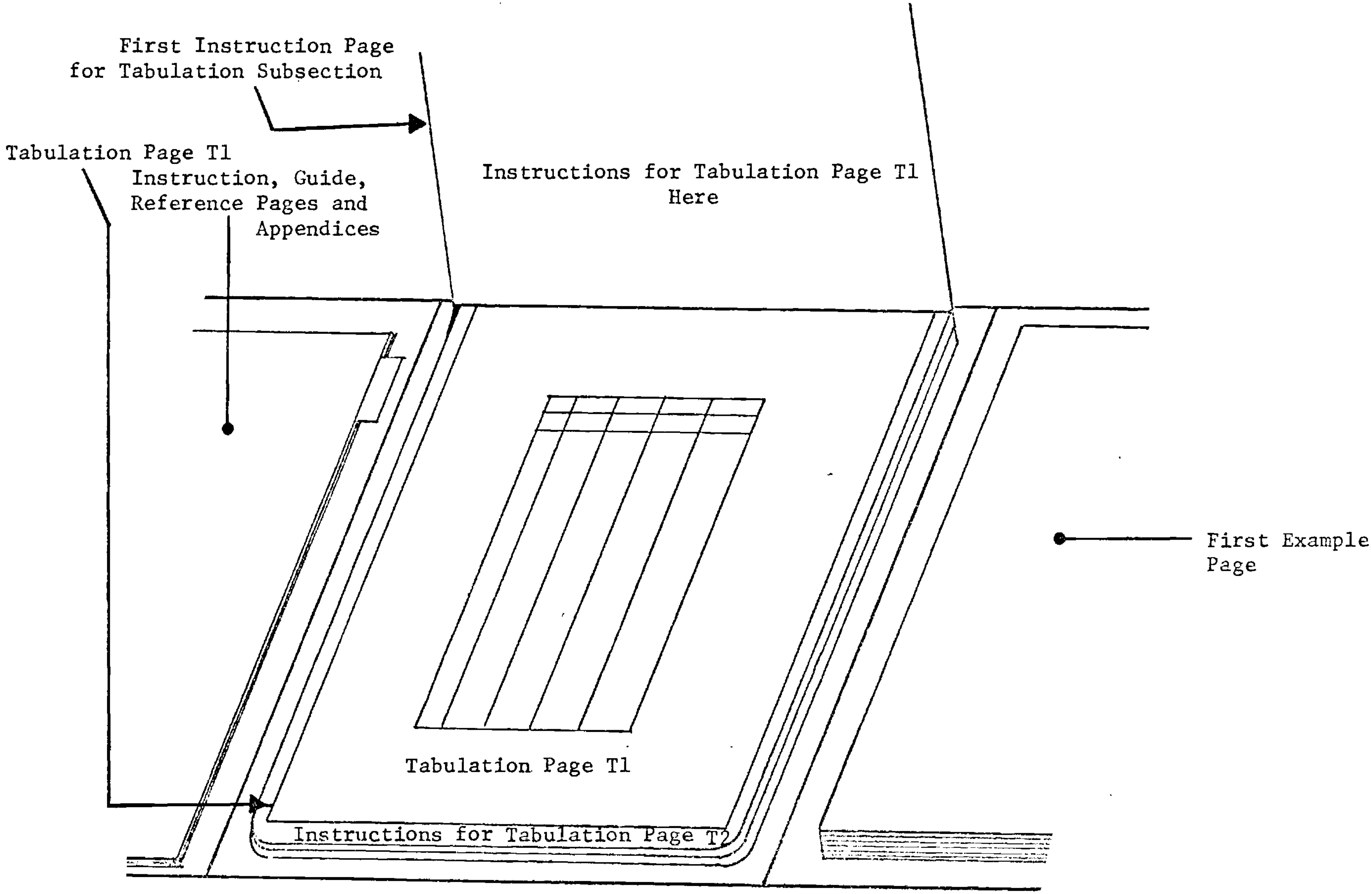

FIGURE 7 Tabulation Subsection Details.

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C-11-608

Telemetry Utilization For Emergency Medical Services Systems

Developed by the
Health Systems Research Center

Under Grant No. R18 HS 00715-02
Division of Health Services Research Analysis
Bureau of Health Services Research
Health Resources Administration
Department of Health, Education, and Welfare

SEAL OF THE GEORGIA INSTITUTE OF TECHNOLOGY 1885 PROGRESS AND SERVICE

Health Systems Research Center
Georgia Institute of Technology
Atlanta June 1974

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SELECTED HSRC REPORTS

Various publications of the Health Systems Research Center are available in either hard copy or microfilm from University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106. When ordering a publication from the list below, refer to the appropriate Hospital Abstract number.

Telemetry Utilization for Emergency Medical Services Systems, USPHS Grant No. R18 HS 00715-02, June 1974, 64 pp. (Hospital Abstract # 12484 OU) [Not available until approximately October, 1974.]

Ambulance Placement Strategies for Emergency Medical Systems, USPHS Grant No. R18 HS 00715-02, January 1974, 133 pp. (Hospital Abstract #11601 HE).

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TELEMETRY UTILIZATION
FOR
EMERGENCY MEDICAL SERVICES
SYSTEMS

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A Programmed Planning Guide
developed by the
Health Systems Research Center

Under Grant No. R18 HS 00715-02

(Harold E. Smalley, Ph.D., Principal Investigator)

Division of Health Services Research Analysis
Bureau of Health Services Research
Health Resources Administration
Department of Health, Education, and Welfare

Health Systems Research Center
Georgia Institute of Technology
Atlanta June 1974

FOREWORD

The present document is a guide for use by health planners and emergency medical services (EMS) personnel to assist in the determination of the feasibility of telemetry utilization in their own EMS systems. This "Guide" was created by the Health Systems Research Center (HSRC) to serve as an aid in designing new and improved EMS systems, and employs information furnished by the user to determine the desirability, possibility, and necessity of using telemetry in order to achieve an effective level of emergency coronary care. Procedures within the Guide permit the user to evaluate, in regard to his own EMS system, the significance of various factors for consideration in the issue of telemetry utilization.

This is the second of a series of outputs from an HSRC project supported since 1972 by a grant from the Bureau of Health Services Research. The project was originally conceived to be an attempt to develop an EMS simulation model. However, reviews of several working papers generated during the first year demonstrated to both the research team and the Bureau the need to redirect project objectives toward the subjects of ambulance location, telemetry, and data collection methodologies. Accordingly, the first of these subjects was addressed in a 133-page report, entitled Ambulance Placement Strategies for Emergency Medical Systems, which was released in January, 1974. The second topic is the subject of the present document; the third subject, data collection methodologies, will be addressed in a subsequent report to be released later this year.

EMS has been a major area of interest within HSRC since early 1969 when the Metropolitan Atlanta Council for Health (MACHealth) established its Task Force on Emergency Health Services. The MACHealth Task Force was charged with the responsibility of identifying problems associated with the provision of emergency medical services in the metropolitan Atlanta area. HSRC participated actively on the Task Force, provided technical systems capabilities, and prepared a number of research, planning, and design proposals for and with MACHealth, which in 1972 became a division of the Atlanta Regional Commission (ARC).

HSRC was commissioned by ARC in 1972 to develop a comprehensive plan and systems design for an improved EMS system for metropolitan Atlanta. This work was done by HSRC under a contract with the Georgia Regional Medical Program and was completed in March 1973. The resulting plan, described in a 566-page report, includes requirements for number, types, and geographical positioning of emergency vehicles; a recommendation of an organization for coordination, operation, and control of the EMS system components; a communications subsystem design; a comprehensive set of procedures for performing the dispatch and control function; recommendations for training EMS personnel; a scheme for evaluating EMS system performance; and recommendations for financing the EMS system.

The Guide described in the present document builds upon these and other EMS experiences, responds to interest expressed by the Bureau of Health Services Research, and partially fulfills an unmet need in the field of health planning.

Harold E. Smalley, Ph. D.
Principal Investigator

PREFACE

Within reference publications dealing with emergency medical services, there are numerous opinions expressed in regard to the issue of telemetry utilization. Since the use of telemetry in EMS systems is a relatively recent concept, many of these opinions are based upon limited experience in the actual operation of telemetry systems. Furthermore, many of the published statements concerning telemetry tend to view the utilization of telemetry from a localized standpoint--i. e., its necessity is viewed as being dependent upon various environmental factors in the writer's own locality. Hence, the statements encountered may or may not be applicable to the individual reader's EMS system.

Addressing this problem, the Guide presented in this report attempts to describe the primary factors which should be addressed when considering the use of telemetry. These factors are presented in a manner which allows the reader to apply the information contained herein directly to most individual EMS systems. The Guide is written for the EMS planner and is directed toward a generalizable EMS system.

The Guide contains narrative sections and a programmed methodology through which the user is instructed to proceed in an orderly and logical fashion. Tabulation space is provided, and through the programmatical format, the user evaluates the feasibility of telemetry in a particular system through a step-by-step process. Primary factors which may influence the decision to use telemetry are discussed, as well as factors of lesser importance which are included in various appendices of the Guide.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

TELEMETRY: DEFINITION, EVOLUTION, AND ISSUES

The use of telemetry in emergency medical services (EMS) systems is presently a topic of much debate. This section of the Guide defines telemetry as it relates to EMS systems, explains the evolution of telemetry as a tool for the treatment of cardiac medical emergencies, and summarizes various opinions regarding the issues of telemetry utilization.

Definition of Telemetry

Generally defined, biomedical telemetry is the technique of measuring and transmitting certain vital life signs (heart, brain, lungs, and temperature) to a distant terminal (24, p. 31). In relation to EMS systems, however, the term "telemetry" usually refers to the measurement and transmission of data describing a patient's heart activity. Such data is ordinarily transmitted from an ambulance or a patient's location to a hospital, where it is recorded and presented as an electrocardiogram (EKG), which is interpreted by a physician or nurse.

To be effective, a telemetry system cannot be limited to the transmission of heart activity signals only. An effective telemetry system must include the capabilities for voice data interchange between ambulance and hospital personnel. Therefore, two-way voice communications capabilities are included in the telemetry system to allow the physician or nurse, after analysis of telemetered data, to direct treatment of the emergency patient. These communications capabilities also allow ambulance personnel to describe the emergency patient's condition, and to report observable responses to treatment.

The term "telemetry", as used in this Guide, refers to the transmission of data describing the electrical activity of the heart, and includes the capabilities for voice data interchange between ambulance personnel and hospital personnel. (It is important to note that an EMS system which does not utilize telemetry may still provide for physician consultation through the use of two-way radio communications. The omission of telemetry from an EMS system should not prohibit the utilization of physician consultation by radio.)

There are several variations of telemetry systems design. (Some of these systems design variations [intermittent and continuous telemetry, channelization, and single versus multiple receiving stations] are discussed in Appendix A. In addition, some systems design considerations [frequency availability, costs, and reliability] are the topics of Appendix B. You should examine these appendices before continuing with the Guide if you are unfamiliar with any of these design topics.) However, all telemetry systems perform the basic functions described above. Thus, the major components of a telemetry system, regardless of minor variations in design, can be described in terms of five major technological functions, as shown in Table 1 (25, p. 9).

TABLE 1

MAJOR FUNCTIONAL COMPONENTS OF A TELEMETRY SYSTEM

Component	Description
Signal Transducer and Conditioner	This component detects heart activity and converts it into electrical signals that can be transmitted by radio.
Radio Transmitter	This unit transmits the output signals from the signal conditioner on a radio frequency. This signal generally is a coded tone or a series of pulses.
Radio Receiver	The coded transmission is detected and channeled to the signal converter and display unit.
Signal Converter and Display Unit	This component reconstructs the signal from the patient and displays or records it in a format that can be interpreted (e.g., an EKG).
Voice Communications	This component provides the capability for voice data interchange by radio between the fixed and mobile terminals.

Evolution of Telemetry

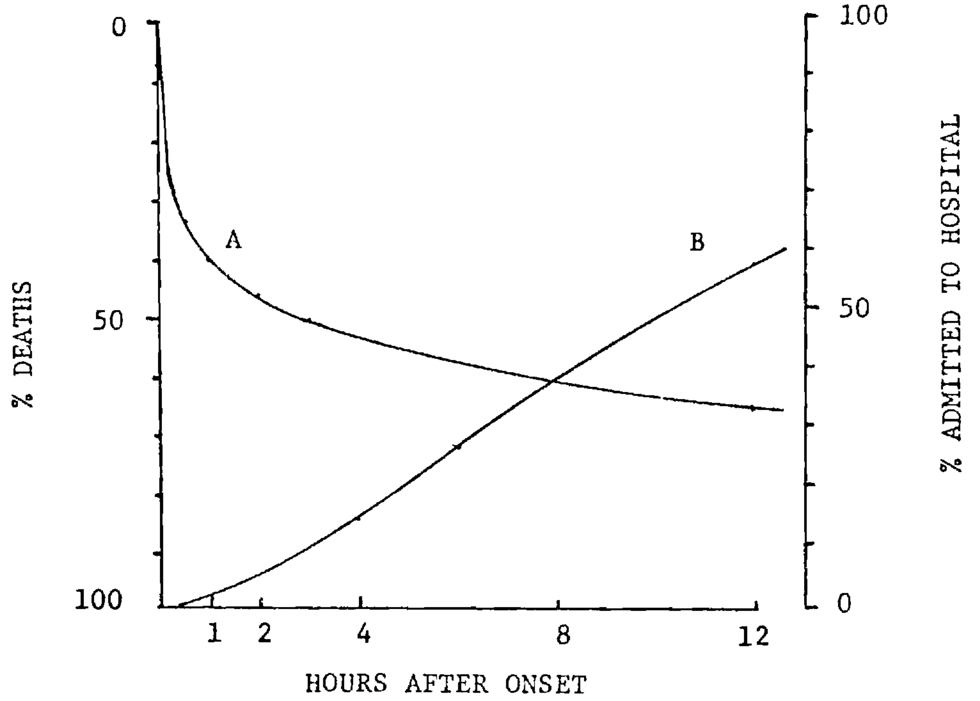
Many victims of medical emergencies suffer from cardiovascular problems, the leading cause of death in the United States. According to a report by a study group on coronary heart disease, an estimated one million people in the United States experience acute myocardial infarction (heart attack) or sudden coronary death each year (5 , p. A-171). The National Center for Health Statistics estimates that there were 735,190 deaths due to heart disease in the United States in 1969. Approximately 359,740 (49%) of these deaths resulted from acute myocardial infartion (22, p. 63).

In an attempt to reduce the magnitude of deaths due to heart disease, coronary care units (CCUs) have been established in hospitals throughout the country. In the past few years, mortality rates associated with hospitalized heart-attack victims have been significantly reduced using the principles of the CCU: prompt detection, effective prevention, and treatment of life-threatening cardiac arrhythmias (abnormal heart rhythms) by drug therapy, defibrillation, and the insertion of pacemakers (5, p. A-171). Prior to the establishment of CCUs, the average mortality rate of patients hospitalized with acute myocardial infarction was approximately 35 per cent (5, p. A-171). Reductions of over 50 per cent in mortality rates have been realized for patients treated in CCUs (13, 14). Although the CCU has proven effective in reducing these mortality rates, it is recognized that the CCU is ineffective in many cases of acute myocardial infarction or sudden coronary death, because many deaths occur before the victim reaches the hospital, where the principles of the CCU can be applied.

The majority of deaths from myocardial infarction occur within a short period of time from the onset of symptoms, and also occur outside the hospital. Figure 1 illustrates that the majority of deaths from myocardial infarctions occur early (approximately 40 per cent within one hour of the onset of symptoms), and that less than 5 per cent of patients with myocardial infarction are admitted to the hospital within the first hour (20 , p. 668).

To significantly reduce mortality rates reflected in Figure 1 any further, an approach differing from in-hospital coronary care is required. J. Frank Pantridge, M. D., the generally-recognized pioneer in mobile coronary care, implemented a system in which a mobile coronary care unit (MCCU), operating in Belfast, Ireland in early 1966, was used to deliver intensive care to the patient at the place where infarction occurred as soon as possible after the onset of symptoms. The MCCU that Pantridge used was initially staffed by a junior physician and a nurse experienced in coronary care. The hospital mortality of patients managed by this MCCU was 12.3 per cent during 1969. The rate for patients admitted to the hospital without MCCU intervention was 22.6 per cent (19, p. 231).

Figure 1. Distribution of Deaths and Admissions as a Funtion of Elapsed Time After Onset of Symptoms. Curve A is percentage of deaths; Curve B, percentage of admissions.



SOURCE: J. Frank Pantridge, M. D. and A. A. Jennifer Adgey, M. B., "Pre-Hospital Coronary Care: The Mobile Coronary Care Unit," The American Journal of Cardiology, Vol. 24, November 1969, p. 668.

Although Pantridge achieved notable results staffing the MCCUs with physicians, this method is not economically feasible for every community, since most physicians are not available for this type of service. Although physicians are available in some communities, delays in reaching them for emergency service can delay treatment and significantly reduce the effectiveness of on-the-scene care. Delays in reaching physicians for emergency service increase the response time of getting medical resources to the scene of an emergency. Response time, which is defined as the elapsed time between the receipt of a request for emergency service and the arrival of an ambulance at the scene of the emergency, is a critical variable in the treatment of persons whose heart has stopped. The probability for effective treatment of this type of coronary problem, referred to as cardiac arrest, is illustrated in Table 2.

TABLE 2

CHANCE OF RESUSCITATION FROM CARDIAC ARREST AS A FUNCTION OF DELAY BETWEEN ONSET AND THE APPLICATION OF CARDIOPULMONARY RESUSCITATION

Delay	Chance of Resuscitation
1 minute	98 out of 100
2 minutes	92 out of 100
3 minutes	72 out of 100
4 minutes	50 out of 100
5 minutes	25 out of 100
6 minutes	11 out of 100
7 minutes	8 out of 100
8 minutes	5 out of 100
9 minutes	2 out of 100
10 minutes	1 out of 100
11 minutes	1 out of 1,000
12 minutes	1 out of 10,000

SOURCE: Jerry Montgomery, Are You Man Enough? The Seattle Plan, Seattle: Physio-Control Corporation, 1971, p. 5.

Since physician-staffed emergency vehicles are not feasible for every community, it is necessary for these communities to utilize a different approach to reduce mortality rates associated with myocardial infarction. Various alternative methods for coping with cardiac emergencies outside the hospital have been proposed and tested. At least six basic levels of treatment capability exist in the methods presently used in the United

States (8, p. 540). These six levels of treating cardiac emergencies can be described as follows:

a. Using a standard ambulance or hearse with one or more attendants, the patient receives oxygen and is transported as quickly as possible to a hospital emergency department (ED).

b. Two trained attendants in a standard ambulance apply cardio-pulmonary resuscitation (CPR) and rush patient to a hospital ED.

c. Two trained attendants in a standard ambulance use CPR, intra-venous (IV) fluid therapy, and a defibrillator; attempt to stabilize patient, then proceed to hospital ED at a moderate speed.

d. Two or three attendants in a specially-equipped ambulance or MCCU use CPR, IV therapy, a defibrillator, and cardiac drugs to stabilize patient before moving him to a hospital, and continue their efforts during transportation, if necessary.

e. Two or three attendants in an ambulance or MCCU use CPR, IV therapy, a defribrillator, cardiac drugs, and telemetry to stabilize the patient and proceed moderately to hospital ED or CCU.

f. A physician or nurse assisted by attendants in an MCCU or ambulance utilize IV therapy, a defibrillator, cardiac drugs, and other necessary supplies and equipment to treat cardiac problems of most types, therby offering definitive therapy at the scene.

For the treatment of cardiac emergencies outside the hospital, the approaches which appear to be most in vogue at the present time are various combinations of *b*, *c*, *d*, and *e* above. However, for the purposes of this Guide, the approaches to emergency coronary care outside the hospital can be considered as being of two basic types. One approach utilizes well-trained Emergency Medical Technicians (EMTs) who are trained and authorized to provide various levels of treatment without telemetry (e. g., EMT can interpret EKGs and administer drugs, EMT can defibrillate but cannot give IV therapy, etc.). The other approach differs from the first only in that it includes the use of telemetry.

The emergence of telemetry as an alternative or a supplemental means for achieving an effective level of emergency coronary care has been accompanied by conflicting views regarding the necessity for its use. The following section presents some of the conflicting views and opinions which presently surround the issue of telemetry utilization.

Conflicting Views and Existing Confusion

Although several EMS systems utilizing telemetry have been developed over the past few years, the health planner may find it difficult to evaluate the telemetry aspect of the EMS system by itself. Limited evaluation data on systems using telemetry are available at the present time, and it is difficult to determine whether reduced mortality rates are a function of telemetry, decreased response times, better-trained emergency personnel, or other extrinsic factors. It is highly possible that a reduction in mortality rates associated with any EMS system is proportional to the total effect of all of the system components, and cannot be attributed to telemetry alone.

Nevertheless, various opinions and judgments in regard to the validity of, and necessity for, telemetry have been expressed by EMS personnel who are familiar with the operational aspects of telemetry within their own systems. These opinions range from telemetry's being indirectly harmful to emergency cardiac patients to telemetry's allowing paramedical personnel to serve as surrogate physicians at the scene of a cardiac emergency.

As noted in Appendix B, in EMS systems which utilize telemetry, failure of transmission and/or reception of telemetered data may occur, thereby delaying treatment to the cardiac patient. In addition, delays which may be encountered in locating someone to interpret telemetered EKGs may prove harmful to the emergency patient. Richard P. Lewis, M. D., of Columbus, Ohio, says of the Columbus EMS system, in regard to telemetry, "...we did did not make telemetry necessary before the fire rescue personnel performed a significant treatment. We had been impressed with regard to the technical difficulties in telemetry and also impressed that ventricular fibrillation is a relatively easy diagnosis to make. Attempting to get a doctor to secure permission to defibrillate may waste one, two, or three minutes, and may in fact cost the patient his life." (7)

The above negative attitude toward the use of telemetry is rebutted by such comments as those which follow in this paragraph. Chief L. O. Martin, Houston Fire Department, states, "It is impossible...to put all the talent needed at the scene of a cardiac case except through the use of telemetry", and feels that telemetry is necessary in order to have a well-rounded EMS system (9 , p. 20). Costas T. Lambrew, M. D., Nassau County Medical Center, points out, "...physicians, including cardiologists, frequently have enough difficulty in interpreting arrhythmia so that it might be unfair and perhaps not in the best interest of the patient to have the paramedic make this difficult interpretation." (9, p. 19) And finally, Joseph A. Fortuna, M. D., Director, Center for the Study of Emergency Health Services, University of Pennsylvania, expresses the opinion, "...for legislative, legal, and malpractice reasons we probably are better off with telmetry..." (9, p. 21)

Although the above comments strongly favor or disfavor the use of telemetry, the following statements are probably indicative of the majority opinion in regard to telemetry utilization: Fred B. Vogt, M. D., Professor of Electrical and Bio-Medical Engineering at the University of Texas at Austin, states, "Paramedics can operate effectively using only voice communications, but there are distinct advantages to having a complete system [telemetry] capability." (9 , p. 18) Captain John M. Waters, Director, Department of Public Safety, Jacksonville, Florida, states that "...telemetry is not necessary if paramedical personnel are trained to the nth degree...and the physicians know them and trust their judgment." (9, p.18) Eugene L. Nagel, M. D., Professor, University of Miami School of Medicine, feels that voice communications between the EMT and the managing physician is the vital ingredient, rather than telemetry. He adds, "The analog signal add-on is important for certain cardiac arrhythmias, but is not essential to the large majority of pre-hospital decisions necessary in medical and surgical emergencies." (9, p. 21) Robert J. Wilder, M. D., a member of the Maryland State Trauma Committee and Assistant Professor of Surgery at Johns Hopkins University, summarizes, "In the future, I would suspect that ambulance personnel would make their own diagnosis of cardiac emergencies using electrocardiographic machines, interpreting the electrocardiographic tracings and giving drugs, after voice communication with a physician and, in fact, in time even without communication...Telemetry is just a stepping stone to reach this goal." (9, p. 20)

As evidenced by the above comments, the utilization of telemetry is viewed with varying degrees of its necessity. However, a reasonably safe statement regarding telemetry is that, while it may not be necessary if well-trained EMTs are legally allowed to perform at their level of capabilities, telemetry can serve very well as a back-up mechanism for routine cardiac emergencies; and for those rare cardiac emergencies seldom seen by the EMT, telemetry can provide the means for prompt diagnosis and subsequent treatment.

Although the preceding statment will probably hold true for any EMS system, the utilization of telemetry may depend upon many factors. The remainder of the Guide includes a discussion of the basic factors which may influence your telemetry decision, and is intended to provide a logical and objective approach for you to reach a valid conclusion about the use of telemetry within your own EMS system. Potential demand upon a telemetry system is one of the factors which can yield some insight into the advisability of its use. This topic is discussed in the following section.

POTENTIAL DEMAND FOR TELEMETRY

The potential demand for telemetry within an EMS system may depend upon several components of the total system, but particularly upon the capabilities of the EMT. Furthermore, the level of emergency coronary care which your system achieves will depend primarily upon the capabilities and actions of the EMT at the scene of the cardiac emergency. These capabilities and actions will be based upon the training and authority given the EMT, upon the EMT's assessment of the emergency, upon oral or written communications from physicians, and possibly upon the interpretation by a physician or nurse of telemetered EKGs. When due consideration is given to the many possible capability levels of the EMT and other EMS components, it may be difficult to accurately predict the demand which will be placed upon telemetry within an EMS system. However, it is worthwhile to examine, as best you can, the potential demand for telmetry in your area prior to deciding on the feasibility of including telemetry in your system. While the potential demand, whether great or small, may not in itself swing your telemetry decision one way or the other, it will provide some insight into the potential usefulness of telemetry to your system, and may serve to place the telemetry issue in a more realistic and practical perspective.

The potential demand for telemetry is examined in this section through the development of *cardiac equations*, and through the application of these equations to an example EMS system. Following the examination of the potential demand for telemetry in an example EMS system, the potential demand for your system will be estimated, using information which you will furnish in the cardiac equations.

Development of Cardiac Equations

Using data from the Jacksonville, Florida and Seattle, Washington EMS systems, the following cardiac equations are derived.

Equation A. During a six-month sample period in the Jacksonville EMS system, 14 per cent (1,680) of the emergency calls received (12,000) were reported as cardiac-related.* This information is used to formulate the following *Equation A*:

Total Emergency Calls x 0.14 = Cardiac-Related Calls

or

TEC x 0.14 = CRC

Equation B. Of the 1,680 (14%) cardiac-related calls, approximately 52 per cent (876) were found to be acute cardiac patients. Thus, *Equation B* is derived below:

Cardiac-Related Calls x 0.52 = Acute Cardiac Patients

or

CRC x 0.52 = ACP

Equation C. During the first year of the operation of a mobile intensive care unit (Medic One) in Seattle, 32 per cent (225) of those patients (707) in which an acute cardiac problem was found were victims of ventricular fibrillation, a condition requiring prompt, appropriate treatment if death is to be prevented (16, p. 6, 5, p. A-171). Using this information, *Equation C* is developed below:

Acute Cardiac Patients x 0.32 = Victims of Ventricular Fibrillation

or

ACP x 0.32 = VVF

Equation D. From Appendix C, which describes in more detail the results of the six-month sample period in Jacksonville, it is seen that of the 876 acute cardiac patients, 18 per cent (155) were dead, beyond any treatment, at the scene of the emergency. Hence, *Equation D* is stated as follows:

Acute Cardiac Patients x 0.18 = Patients Dead on Arrival of Ambulance

or

ACP x 0.18 = DOA

* See Appendix C for additional information.

Equation E. Appendix C also indicates that 106 (12%) of the 876 acute cardiac patients died in the field after CPR was administered. As stated in Appendix C, most of these 106 victims were "clinically dead" upon the arrival of an ambulance, but CPR was administered anyway, since the exact time of death was unknown and resuscitation might have been effective.* *Equation E* is stated below:

Acute Cardiac Patients x 0.12 = Patients Dying in Field After CPR

or

ACP x 0.12 = DF*CPR

The cardiac equations stated above are summarized in Table 3.

TABLE 3

CARDIAC EQUATIONS

Designation	Equation
Equation A	TEC x 0.14 = CRC
Equation B	CRC x 0.52 = ACP
Equation C	ACP x 0.32 = VVF
Equation D	ACP x 0.18 = DOA
Equation E	ACP x 0.12 = DF*CPR

Anticipated Telemetry Utilization Example EMS System

Through the application of the cardiac equations from Table 3 to hypothetical data from an example EMS system, the frequency with which EMTs might find it necessary to use telemetry (potential demand) can be estimated.

Example EMS System. Using the generally recognized estimate of one emergency call per 10,000 population per day, an example system of 1,000,000 population will have approximately 100 calls per day. (Note: Each of the following computations is on a daily basis.)

---

*Clinical death occurs at the moment when a person ceases to breathe and his heart stops beating (4, p. 1).

<u>Step 1</u>. Using *Equation A* in Step 1 below, the approximate number of cardiac-related calls per day in the example system is determined.

$$\text{TEC} \times 0.14 = \text{CRC}$$
$$100 \times 0.14 = 14 \text{ CRC}$$

These 14 cardiac-related calls represent apparent and potential subjects for the use of telemetry, or the potential demand for telemetry in this example EMS system.

<u>Step 2</u>. Using *Equation B*, the number of acute cardiac patients is found.

$$\text{CRC} \times 0.52 = \text{ACP}$$
$$14 \times 0.52 = 7.3 \text{ ACP}$$

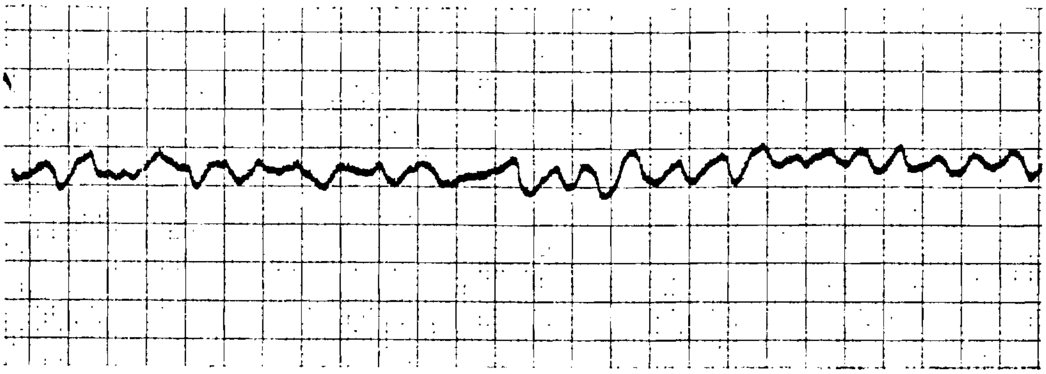
As seen in this step, only 7.3 patients per day will be acute cardiac patients. Assuming that the EMT is capable of determining, <u>without</u> the use of telemetry, which of the 14 cardiac-related calls is <u>not</u> an acute cardiac patient (e.g., by interpreting the EKG from an oscilloscope or strip-chart recorder), only 7.3 patients remain as being potentially subject to telemetry.

<u>Step 3</u>. *Equation C* in Step 3 below is used to determine how many of the 7.3 acute cardiac patients will be victims of ventricular fibrillation.

$$\text{ACP} \times 0.32 = \text{VVF}$$
$$7.3 \times 0.32 = 2.33 = 2.3 \text{ VVF}$$

It has been demonstrated that highly motivated and well-trained EMTs can achieve a high degree of accuracy in the interpretation of common EKG arrhythmias, especially the life-threatening ones (22, p. 68). As stated previously, ventricular fibrillation is a relatively easy diagnosis to make (7). Furthermore, the EKG pattern associated with ventricular fibrillation should be easily recognizable by the EMT, as illustrated in Figure 2. Thus, the 2.3 victims of ventricular fibrillation can be identified without the use of telemetry, thereby reducing potential subjects of telemetry to 5.0 (7.3 ACP - 2.3 VVF = 5.0).

Figure 2. Example EKG Pattern of Ventricular Fibrillation.



SOURCE: California Heart Association, Introduction to Arrhythmia Recognition, San Francisco, 1968, p. 17.

Step 4. *Equation D* is used in Step 4 to determine the victims who are dead upon arrival of the ambulance, and consequently are not subject to the utilization of telemetry. It is assumed that the EMT is capable of identifying these victims without the use of telemetry (although EKG confirmation may be desirable).

$$\text{ACP} \times 0.18 = \text{DOA}$$
$$7.3 \times 0.18 = 1.31 = 1.3 \text{ DOA}$$

These 1.3 dead-on-arrival victims further reduce the patients subject to telemetry to 3.7 (7.3 ACP - 2.3 VVF - 1.3 DOA = 3.7).

Step 5. Lastly, *Equation E* is used below to determine an estimate of the acute-cardiac patients who die in the field after CPR has been administered by ambulance personnel.

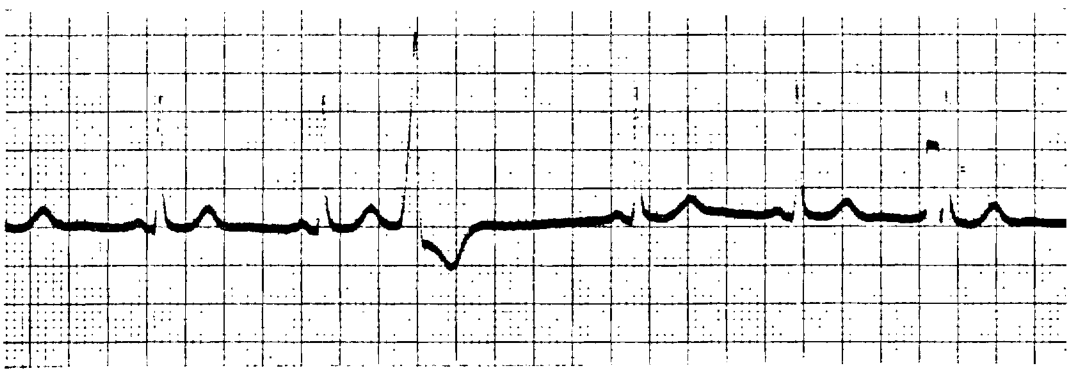
$$\text{ACP} \times 0.12 = \text{DF*CPR}$$
$$7.3 \times 0.12 = 0.87 = 0.9 \text{ DF*CPR}$$

The American Heart Association advises that CPR is necessary when circulation ceases [e. g., ventricular fibrillation or asystole] (3, p. 2). The assumption is made that a well-trained EMT can recognize those EKG patterns which correspond to a cessation of circulation. Applying this assumption to the results of the above equation, it follows that all of the victims who died in the field after CPR was administered (0.9 DF*CPR) exhibited EKG patterns recognizable by the EMT without the use of telemetry. Consequently, this further reduces the patients subject to telemetry utilization to 2.8 (7.3 ACP - 2.3 VVF - 1.3 DOA - 0.9 DF*CPR = 2.8).

Of the 2.8 patients remaining who are potentially subject to the use of telemetry, there is a distinct possibility that some of them do not have myocardial infarction, and therefore may not be candidates for definitive treatment from the EMT; and hence may not require EKG interpretations by a physician (e.g., victims of congestive heart failure). In addition, the most common arrhythmias _not_ mentioned previously (premature ventricular contractions, ventricular tachycardia, A-V block, and bradycardia) should all be recognizable by a well-trained EMT. Example EKG patterns of these arrhythmias are illustrated in Figures 3, 4, 5, and 6.

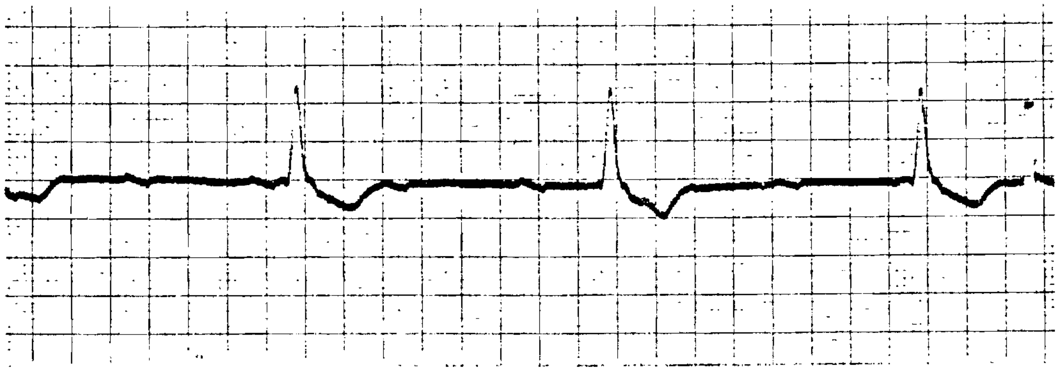
From the above discussion, assumptions and computations, it can be concluded that probably less than 2.8 per cent of the emergency calls per day in an EMS system will be patients who are potential subjects for the use of telemetry.

Figure 3. Example EKG Pattern of Premature Ventricular Contractions.



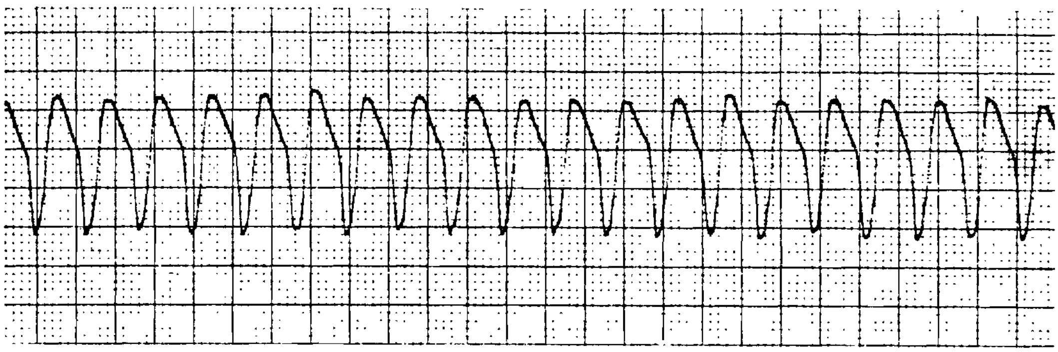
SOURCE: California Heart Association, _Introduction to Arrhythmia Recognition_, San Francisco, 1968, p. 15.

Figure 4. Example EKG Pattern of 3rd Degree (Complete) A-V Block.



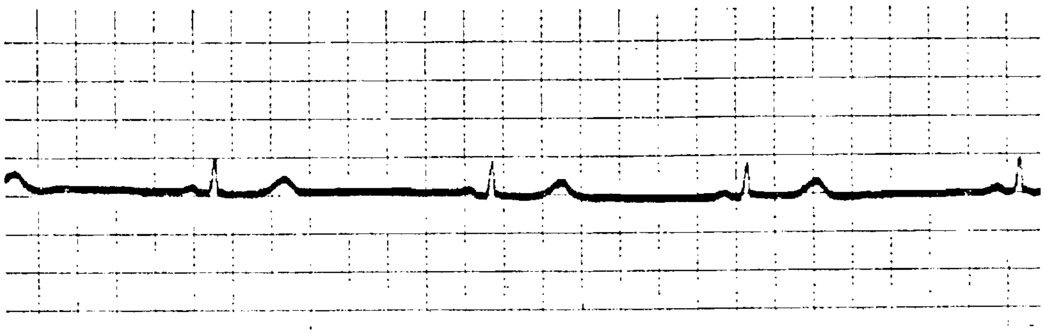
SOURCE: California Heart Association, Introduction to Arrhythmia Recognition, San Francisco, 1968, p. 13.

Figure 5. Example EKG Pattern of Ventricular Tachycardia.



SOURCE: California Heart Association, Introduction to Arrhythmia Recognition, San Francisco, 1968, p. 17.

Figure 6. Example EKG Pattern of Sinus Bradycardia



SOURCE: California Heart Association, Introduction to Arrhythmia Recognition, San Francisco, 1968, p. 7.

While the example EMS system in this subsection is based upon realistic figures and reasonable assumptions, it should be noted that the percentage of cardiac-related calls for some EMS systems is slightly higher than the 14 per cent figure used in the example.* Hence, the potential demand for telemetry in these systems could be somewhat higher than the potential demand derived in the example. Additionally, there may be instances other than cardiac-related calls when the employment of telemetry is both useful and desirable. Dr. Gary J. Anderson of Indianapolis, Indiana, advises that any patient with suspected myocardial infarction or severe angina should be telemetered, as well as patients with manifest congestive heart failure, digitalis toxicity, or drug overdoses (7). Dr. Anderson points out that the Indianapolis system has even found patients with aspirin overdoses demonstrating severe ventricular arrhythmias (7). If similar procedures of telemetering these types of patients are followed in your EMS system, the potential demand for telemetry may be considerably higher than the demand indicated in the example system. In addition, if EMTs in your system are not trained to recognize the arrhythmias mentioned in the example above, the potential demand for telemetry will be increased. While these and other considerations may affect the potential demand for telemetry in your system,

*Advanced Technology Systems, Inc. reports that approximately 20 per cent of all emergency calls involve coronary cases, based upon experience in Houston, Miami, and other urban areas (2 , p. III-17).

the example is intended to provide you with some insight into a means for estimating potential demand for telemetry within any given system.

Anticipated Telemetry Utilization
Your EMS System

As previously indicated, there are several factors which may influence the potential demand upon a telemetry system. However, the capabilities of the EMT and the size of the population to be served by the EMS system are perhaps the most important factors you should consider when estimating the potential demand upon telemetry in your system.

The population served by your EMS system can be considered as a constant factor which remains relatively unchanged whether you use telemetry or not. The capabilities of the EMT, on the other hand, may vary from system to system, and each variation may affect potential demand upon telemetry. However, for the purpose of estimating the potential demand for your system, the consideration of only two alternative levels of EMT capability should be adequate to form a preliminary opinion of whether or not telemetry is feasible for your EMS system. These two alternative levels are presented as Method I and Method II below. You should choose the method for determining potential demand upon telemetry which is the closer description of conditions in your EMS system, then proceed as directed. (With the exception of the capabilities of the EMT, conditions in each method are assumed to be identical. It is also assumed in each method that the EMT is legally allowed to administer drugs and defibrillate under written or verbal orders of a physician.)

Method I. EMTs are not trained to recognize arrhythmias, and must rely upon telemetry for the purpose of diagnosing cardiac patients.

Method II. EMTs are trained in arrhythmia recognition, and are capable of diagnosing most arrhythmias through the interpretation of EKGs shown on an oscilloscope or an EKG strip (without telemetry).

If Method I is the better description of conditions in your EMS system, proceed to the Method I calculations which follow. If Method II is your choice, proceed to the Method II calculations on page 20.

Method I

Step 1. Determine the population for your EMS region (e.g., from census bureau records) and enter the population figure in the space below.

POPULATION FOR YOUR EMS SYSTEM SERVICE AREA

Step 2. Divide the figure entered in the space above by 10,000 (as shown in the equation below) to determine the total number of emergency calls per day for your EMS system.* Enter your answer in the box below the example equation.

$$\frac{\text{Population}}{10{,}000} = \text{Number of Emergency Calls Per Day}$$

APPROXIMATE NUMBER OF EMERGENCY CALLS PER DAY

*Based upon the estimate of one emergency call per 10,000 population per day.

Step 3. Multiply the approximate number of total emergency calls (TEC) per day shown in the box above by 14 per cent to determine the number of cardiac-related calls per day.* (This procedure is illustrated in the example equation below.) Enter your result in the box below the example equation.

$$TEC \times 0.14 = CRC$$

CARDIAC-RELATED CALLS

Step 4. Since the EMT is not trained in arrhythmia recognition, the number of cardiac-related calls represents a rough approximation of the potential demand for telemetry in your system. Enter the figure from the "Cardiac-Related Calls" box in the space below, and proceed to the discussion following the "Method II" box on page 22.

APPROXIMATE POTENTIAL DEMAND
FOR TELEMETRY PER DAY
(METHOD I)

Method II

Step 1. Determine the population for your EMS region (e.g., from census bureau records) and enter the population figure in the space below.

POPULATION FOR YOUR EMS SYSTEM SERVICE AREA

---

*This procedure was expressed as a cardiac equation in a previous section, and is shown as *Equation A* in Table 3.

Step 2. Divide the figure entered in the space above by 10,000 (as shown in the equation below) to determine the total number of emergency calls per day for your EMS system.* Enter your answer in the box below the example equation.

$$\frac{\text{Population}}{10{,}000} = \text{Number of Emergency Calls Per Day}$$

APPROXIMATE NUMBER OF EMERGENCY CALLS PER DAY

Step 3. Multiply the approximate number of total emergency calls (TEC) per day by 2.8 per cent to determine the potential demand per day for telemetry in your system.** (This procedure is illustrated in the example equation below.) Enter your result in the space below the example equation.

$$\text{TEC} \times 0.028 = \text{Potential Telemetry Demand}$$

APPROXIMATE POTENTIAL DEMAND
FOR TELEMETRY PER DAY
(METHOD II)

---

*Based upon the estimate of one emergency call per 10,000 population per day.

**In the preceding discussion and calculations relating to the example EMS system, in which the capabilities of the EMT were similar to those in Method II, it was concluded that probably less than 2.8 per cent of the total emergency calls per day will be potential subjects for the use of telemetry.

The potential demand for telemetry in your EMS system, which you determined through Method I or Method II, should give you some preliminary indication of the necessity for telemetry within your system, based upon potential demand. However, although the use of telemetry may not be indicated from the standpoint of potential demand, telemetry may be desirable for other reasons, as previously stated. As a back-up in judgment cardiac cases, and for those arrhythmias which the EMT has neither the training nor the experience to recognize, telemetry can be extremely valuable. In addition, telemetry can serve as an educational tool for the EMT, allowing the physician to check on EKG interpretations made by the EMT and to advise him accordingly.

If the potential demand for telemetry in your system is sufficient to warrant further investigation into the feasibility of its use, or if the back-up capability or other characteristics of telemetry indicate that its use might be desirable, you should proceed with the Guide. If such is the case, turn to page 23 and continue with the Guide.

If, in your opinion, the potential demand for telemetry or your interest in various characteristics of telemetry is insufficient to warrant its use, you will probably have to depend primarily upon the capabilities and expertise of the EMTs within your system in order to achieve an effective level of emergency coronary care. However, you may wish to continue with the Guide for informational purposes. If so, turn to page 23 and continue.

PRIMARY FACTORS FOR CONSIDERATION

In the previous section of the Guide, the potential demand for telemetry in your EMS system was estimated. In Appendix B, other factors (frequency availability, cost, reliability) of varying degrees of importance to the telemetry issue were briefly discussed. This section of the Guide discusses six factors of primary importance to the determination of the feasibility and necessity of using telemetry in an EMS system. These factors of primary importance are: (1) legal aspects, (2) physician attitude, (3) receiving personnel, (4) transmitting personnel, (5) geographical characteristics, and (6) population characteristics.

Each factor for consideration is presented in a question-and-answer format, accompanied by brief discussions of pertinent information and directions for proceeding with the Guide. While the factors which follow are not necessarily addressed in order of importance, it is necessary that the sequence of the subsections be adhered to in order to reach a valid conclusion as efficiently and effectively as possible.

Legal Aspects

As previously mentioned, the utilization of telemetry within an EMS system may depend to a great extent upon the legal authority of the EMT to administer drugs and defibrillate in cases of cardiac emergencies. Since the laws governing the actions of EMTs may vary considerably for different systems, it is imperative that you determine exactly what degree of authority the EMT within your EMS system possesses.

Before considering what functions the EMT can legally perform under various circumstances (e.g., using telemetry, using radio communications, etc.), it is important to determine what functions the EMT is allowed to perform without any special considerations.

Question 1: Within your EMS system, are EMTs authorized to administer drugs and defibrillation to victims of a heart attack?

Yes: An affirmative response indicates the potential for achieving an effective level of emergency coronary care within your EMS system, with or without telemetry. Turn to the Tabulation Page on page 40 and enter an "x" in the "Dependent Positive" column which corresponds to this question. Then proceed to Question 2 on page 25. (Instructions for proceeding with the Guide are also provided on the Tabulation Page.)

No: This answer indicates the necessity for some revision within your area regarding EMT performance limitations. The laws governing EMTs should be conducive to the achievement of an effective level of emergency coronary care, and revisions in the EMT laws should correspond to this goal. Utilizing CPR alone, instead of with defibrillation and cardiac drugs, as the primary method of treating heart attacks can reduce the patient's chances for survival. Captain Waters of Jacksonville states, "While they [EMTs] can carry out CPR, and have done so in a number of cases, this method over a period of time usually results in progressive hypoxia and acidosis, and the chance of salvage declines steadily with delay in definitive treatment." (10, p. 45) The same viewpoint is shared by Gearty et al., who state, "The risks from massage are greater than those from defibrillation, and in primary ventricular fibrillation the chance of a successful outcome after massage is less. Because of the efficiency and safety of defibrillation in trained hands it is essential that all people coming into frequent contact with cases of cardiac arrest should be trained to recognize ventricular fibrillation and to perform external defibrillation...The ideal treatment for ventricular fibrillation is immediate countershock." (11, p. 34) In addition to these disadvantages, CPR is difficult to administer, especially in a moving vehicle.

A similar argument can be advanced for the administration of drugs by the EMT. The American Heart Association states, "...early use of positive inotropic [strengthening muscle contractility] or vasoactive drugs cannot be over-emphsized since the restoration of normal function in certain instances may be impossible without these agents." Also required is the prompt administration of sodium bicarbonate to combat profound metabolic acidosis. (3, pp. 4-6)

The Department of Health, Education, and Welfare advises that if an EMT is "...not legally authorized to administer drugs and to defibrillate heart attack victims, then training in the use of telemetry equipment would serve little purpose." (24, p. 5)

Therefore, if you answered this question negatively, you should attempt to change the conditions leading to a negative response. If you are unable to change these conditions, telemetry will be of limited value to your system. Thus, you may stop at this point, unless you can foresee answering this question positively within the near future. If the latter is the case, turn to the Tabulation Page on page 40 and enter an "x" in the "Negative" column which corresponds to this question. Then proceed to Question 2.

Question 2: If authorized to administer drugs and to defibrillate, must such actions be dependent upon the utilization of telemetry?

No: Turn to page 40, enter an "x" in the fourth column ("Dependent Negative") corresponding to Question 2, and return to the discussion following the narrative which accompanies the "Usually" answer to this question.

Yes: An affirmative response suggests that your system should use telemetry, at least until the question can be answered differently. Such a reponse does not necessarily reflect the practicality or necessity of using telemetry, however. Therefore, you should proceed with the Guide. Turn to page 40, enter an "x" in the first column ("Positive") corresponding to Question 2, and return to the discussion following the narrative which accompanies the "Usually" answer to this question.

Usually: A response such as this does not reflect the need for telemetry within an EMS system, nor does it rule out its value to an EMS system. (An example situation eliciting this response is a system in which the EMT is routinely and normally dependent upon telemetry, yet which has provisions for the EMT to perform appropriate treatment in the absence of telemetry during instances of equipment or transmission failure.) In responses similar to this, you should proceed with the Guide. Turn to page 40, enter an "x" in the second column ("Dependent Positive") corresponding to Question 2, and return to the discussion immediately following this answer.

It is worthwhile to note the importance of flexibility within your system in regard to legal issues and implications. If the utilization of telemetry is indicated from your above answers, be prepared for revision in the law which could make your EMS system more effective, and work for these changes if so desired. During the early phases of the Oregon Coronary Ambulance Project organized in 1969, EMTs were limited in the types of medications which they could administer. Approximately one year later, their limitations were lessened when the Oregon Board of Medical Examiners ruled that, under specified conditions, it would be appropriate and legal for the ambulance attendants to give medication, such as atropine, parenterally on radio command by physicians (22, pp. 63-68). Since that time, the authority of the Oregon EMT to perform defibrillation and to administer drugs has been expanded so that these acts can now be performed under written or oral authorization of a physician. Similarly, a ruling by the Attorney General of the State of Georgia on the Medical Practice Act of Georgia states that properly trained EMTs may administer drugs and IV fluids when directed by a physician through oral communications.

Physician Attitude

Although EMTs may be legally empowered to defibrillate and administer drugs without the use of telemetry, the medical community within your system may prefer to use it. The study group on coronary heart disease cited previously in the section on the evolution of telemetry recommended that personnel who staff emergency vehicles be able to recognize and treat cardiac arrhythmias, perform CPR, and be authorized to initiate drug therapy and defibrillation, preferably under a physician's supervision through voice communications. However, the study group, consisting of one nurse and eight physicians, also recommended telemetry. (5, pp. A-174-75) If the personnel staffing emergency vehicles have the capabilities recommended by the study group, it is conceivable that an effective level of emergency coronary care can be achieved without the use of telemetry. Nevertheless, telemetry was recommended by the group.

As previously indicated, legislation in Georgia authorizes trained EMTs to administer drugs, without telemetry, if instructions are provided. Although this authorization exists, Metro Ambulance Service (a private company operating in metropolitan Atlanta, Georgia) utilizes telemetry in its vehicles due in part to the fact that the physicians associated with Metro prefer its use, except in cases of cardiac arrest (21).

Question 1: Do physicians within your EMS system prefer the utilization of telemetry as a prerequisite to the treatment (defibrillation and drug administration) of coronary cases by the EMT? (This question is to ascertain the probability of physician cooperation in the system. It should be answered as if the degree of "preference" corresponds to an expected amount of physician cooperation.)

No: Turn to page 40 and enter an "x" in the fourth ("Dependent Negative") column corresponding to Question 1 of the Physician Attitude section. Also enter the letters "NA" (not applicable) in each space corresponding to Question 3 of this section. After completing these tasks, proceed to the following section on receiving personnel, skipping Questions 2 and 3 which follow.

Yes: While this answer suggests that you probably should have telemetry, it does not address the feasibility or necessity of telemetry utilization. Therefore, you should proceed with the Guide. Turn to page 40, enter an "x" in the "Dependent Positive" column corresponding to Question 1 in the Physician Attitude section, then proceed with Question 2.

Usually: Turn to page 40, enter an "x" in the "Dependent Positive" column corresponding to Question 1 in the Physician Attitude section, then proceed with Question 2 below. (An example system evoking this response is one in which physicians may prefer a telemetered EKG in most cases, yet provide written orders for the EMT, based upon his own interpretation of an EKG strip or an EKG shown on an oscilloscope, to defibrillate victims of ventricular fibrillation without delaying treatment until an EKG can be telemetered and directions communicated.)

Question 2: If physicians prefer the use of telemetry in some cardiac emergencies, what are the specific types of cardiac emergencies, and with what frequency does each occur? (List below.)

	Arrhythmia	Frequency*
1.	(e.g., bradyarrhythmia)	
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

*For assistance in estimating the frequency of occurrence of various arrythmias, see the discussion on page 28.

In the previous section on the potential demand for telemetry, you estimated the anticipated utilization of telemetry in your system, based upon one of two methods. In Method I, it was estimated that 14 per cent of the total emergency calls per day would be potential subjects for telemetry. In Method II, it was determined that probably less than 2.8 per cent of the emergency calls per day will be patients who exhibit arrhythmias requiring the use of telemetry for EKG interpretation. However, the discussion on potential demand did not include estimates of the frequency of occurrence of any arrhythmias other than those that lead immediately to death. Therefore, if you listed any cardiac emergencies above which were not addressed in the Potential Demand for Telemetry section, you should either measure or estimate the frequency with which each emergency occurs.

The method by which you identify this frequency of occurence should be one which is appropriate and convenient for you. As a suggestion, however, you may be able to estimate the frequency of occurence for the arrhythmias you listed from hospital ED records or from similar sources.* (If so, you should make such an estimate at this time, then continue with Question 3 on page 30, proceeding as directed.) If this, or a similar approach is not feasible, Table 4 should be examined to give some indication of the types of cardiac emergencies which you might encounter in your system. Table 4 is developed from a three-month period in the Columbus, Ohio EMS system. During this period, three emergency ambulances were in use, and approximately 200 patients were seen each month, with about 14 per cent of them having documented acute myocardial infarction (7). The characteristics of the myocardial infarctions which were seen in the time reported are illustrated in Table 4. The table can perhaps be used as a basis for estimating the frequency of occurrence of some of the cardiac emergencies which you may have listed. For example,

*If hospital ED records are examined to estimate the frequency of occurrence for various arrhythmias, only records of cardiac patients who arrived by ambulance should be sampled. (Patients arriving by other means are not candidates for telemetry; hence, their records should not be included in the sample.)

TABLE 4

CHARACTERISTICS OF MYOCARDIAL INFARCTIONS SEEN DURING THREE-MONTH PERIOD IN COLUMBUS, OHIO SYSTEM

Characteristic	Per Cent*
Acute Pulmonary Edema	10
Significant (Requiring Therapy) Arrhythmia	58
Bradyarrhythmia	26.5
Supraventricular Tachycardia	17
Ventricular Tachycardia Ventricular Fibrillation Heart Block Asystole	28
Premature Ventricular Contractions Only	16
Shock or Hypotension	25
Hypertension	34

*Some patients exhibited more than one characteristic listed; hence, the percentages, when totalled, equal more than 100 per cent.

if you listed "bradyarrhythmia" in response to Question 2, you can estimate from Table 4 that 26.5 per cent of the patients with myocardial infarction will exhibit this characteristic. If only 14 per cent of all the patients seen in your system have documented myocardial infarction, however, the 26.5 per cent of patients exhibiting bradyarrhythmias will be only 3.7 per cent of the total patients seen ($0.14 \times 0.0265 = 0.0371 = 3.7\%$). Using similar reasoning, calculate the frequency of occurrence of the cardiac emergencies which you listed in Question 2. For those cardiac emergencies which you listed that are not shown in Table 4, estimate the frequency of occurence as best you can. After completing these tasks, answer Question 3 which follows, and proceed with the Guide as directed.

Question 3: Do the cardiac emergencies which you listed in response to Question 2 occur frequently enough to warrant the use of telemetry?

Yes: Turn to page 41, enter an "x" in the "Dependent Positive" column corresponding to Question 3 in the Physician Attitude category, and proceed with the Receiving Personnel section which follows on this page.

No: Although this answer indicates that the use of telemetry may not be justified, from the standpoint of expected frequency of use, there may be other reasons for having telemetry in your system. Turn to page 41 , enter an "x" in the "Dependent Negative" column corresponding to Question 3 in the Physician Attitude category, and proceed with the Receiving Personnel section which follows.

Receiving Personnel

A vital part of a telemetry system is the personnel at a remote point from the ambulance who receive and interpret the telemetered information and issue directions to the EMT. Prior to answering questions regarding the availability of these personnel, it is necessary to determine who (physicians, nurses, etc.) these people will be in your system. Although there has been an increase (12 per cent) in the number of emergency facilities having 24-hour in-house physician service within the past four years, there are still only 29 per cent of hospitals receiving emergency patients who offer this capability.* These figures indicate that physicians may not be available to interpret telemetered information. Even if physicians are technically available (e.g., within the hospital), there may be some delay in getting the physician to the receiving area, as previously noted.

The City of Miami Fire Department Rescue Service, in its initial stages of telemetry utilization, used a physician-manned receiving area in the hospital for telemetered information (18, p. 333). A system in Indianapolis, Indiana, used the CCU as the receiving point (6, p. 643). Though diagnosis was provided in this latter instance by the CCU physician-in-charge, it has been demonstrated that the CCU nurse can provide adequate direction and supervision to the EMT in a large number of cases.

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*Percentages represent the results of surveys obtained from 37 states in 1969, and 35 states in 1973 (12, p. 334).

Nagel et al. report, "It is commonly acknowledged that hospital CCUs have reduced in-hospital mortality from myocardial infarction significantly... Credit for this achievement is freely given to the specially trained coronary care nurses who are charged with responsibility for immediate recognition of life-threatening arrhythmias and vested with authority to initiate lifesaving measures." (18, p. 337) Hence, the CCU nurse may serve, in some instances, as the person who interprets routine telemetered EKGs, and advises the EMT accordingly. However, many CCUs are staffed by solitary nurses. When an emergency arises within the CCU simultaneously with an emergency requiring telemetry within the ambulance, the expectations of the solitary nurse may be too great (7).

After you have identified, through an analysis of existing resources within your EMS region, the resource personnel who can feasibly serve on the receiving end of your telmetry system, you must question their availability.

Question 1: Are personnel immediately available on a twenty-four hour basis within your system to read telemetered EKGs and issue directions regarding treatment of the EMT? (Immediate availability is defined here as no delay, or an acceptable delay*, in using the services of the receiving personnel for telemetry purposes.)

Yes: This response indicates that a necessary component of a telemetry system is available. Turn to page 41, enter an "x" in the "Dependent Positive" column corresponding to this question. Also enter the letters "NA" in each possible answer space for Question 2 and proceed with the Transmitting Personnel section on page 32, skipping Question 2.

No: Your effective level of emergency coronary care will be dependent upon the performance of emergency vehicle personnel without telemetry, at least part of the time. Turn to page 41, enter an "x" in the "Dependent Negative" column corresponding to Question 1 in the Receiving Personnel category, and continue with Question 2.

*An "acceptable delay" may vary from system to system. For the purpose of answering Question 1, however, an "acceptable delay" should be considered as being less than one minute.

Question 2: If not immediately available on a twenty-four hour-a-day basis, are these personnel available a sufficient amount of time, in your opinion, to justify the use of telemetry?

No: This answer indicates that your system should not use telemetry, unless there are causes (e.g., physician attitude, EMTs not authorized to defibrillate or administer drugs without telemetry, etc.) which encourage the use of telemetry even though it may not be justified in terms of utilization. If there are extraneous factors such as these to consider, you may want to proceed with the Guide. If so, turn to page 41, enter an "x" in the "Dependent Negative" column for this question, and proceed to the following section on transmitting personnel.

Yes: This answer indicates that you could utilize telemetry part of the time, but does not necessarily reflect the need for its utilization. Systems using part-time telemetry might be those with receiving personnel available during peak emergency hours - possibly one or two eight-hour shifts per day. Turn to page 41, enter an "x" in the "Dependent Positive" column for this question, and proceed to the following section on transmitting personnel.

Transmitting Personnel

For the purpose of proceeding with the Guide, the assumption is made that EMTs are available in your EMS system, since they are a vital part of an EMS system, whether that system uses telemetry or not. Indeed, of all the factors to be considered in determining the value of telemetry in your system, perhaps none affects the others as much as the issues regarding EMTs at the transmission end of telemetry. In a paper presented to the National Symposium on Community Emergency Medical Services, in Houston, Texas, Fred B. Vogt, M. D., states, "...effective and meaningful services cannot be provided if there is not total and responsive involvement of that component of the system in the total emergency medical service system. The telemetry of the electrocardiogram is of no benefit if a physician cannot advise the emergency medical technician, or if the EMT does not have the equipment or drugs to provide treatment, or if the EMT is not properly trained in the execution of such procedures." (26, p. 7)

It has been demonstrated that well-trained EMTs can achieve a high degree of accuracy in the interpretation of common EKG arrhythmias, especially the life-threatening arrthymias, and can effectively treat certain cardiac emergencies (22, p. 68). In the Columbus, Ohio EMS system, the percentage of myocardial infarctions correctly diagnosed by physicians on board an MCCU was 87 per cent; by EMTs on board an MCCU without a physician, 83 per cent (7). EMTs in the Columbus system are trained to administer drugs and perform defibrillation under standing orders, without direct physician supervision or the utilization of telemetry (8 , p. 128). As referred to previously, ambulance personnel in Oregon perform under written or oral authorization from a physician. In short, regardless of the use of telemetry, EMTs have demonstrated their ability to recognize and treat cardiac emergencies effectively.

Question 1: Are EMTs in your system adequately trained in the treatment of life-threatening arrhythmias?

Yes: EMT training in the treatment of life-threatening arrhythmias is necessary (if an effective level of emergency coronary care is to be achieved) in both systems which use telemetry and those which do not. Turn to page 41 and enter an "x" in the "Dependent Positive" column for this question. Then proceed to Question 2.

No: This answer indicates a need for the implementation of a training program which will enable EMTs to treat certain cartain cardiac emergencies. Without the EMT's capability to treat cardiac emergencies, telemetry is of little use. If you are presently unable to answer this question in a different way, turn to page 41 and enter an "x" in the "Negative" column corresponding to this question. You should proceed with the Guide only if you envision being able to answer this question affirmatively within the very near future. If such is the case, proceed to the following question.

Question 2: Are EMTs in your system adequately trained in the detection and recognition of life-threatening arrhythmias?

Yes: EMT capability for both the treatment and the detection and recognition of life-threatening arrhythmias lessens the necessity for telemetry utilization. However, you may want to use telemetry for those arrhythmias which occur so infrequently that the EMT has neither the training nor experience to recognize. In either case, you should proceed with the Guide. Turn to page 42, enter an "x" in the "Dependent Negative" column which corresponds to this question, then proceed to the section on geographical characteristics which follows.

No: If able to treat certain arrhythmias, but unable to detect and recognize the life-threatening ones, you should strongly consider either the utilization of telemetry or the implementation of a training program for EMTs which emphasizes the detection and interpretation of life-threatening arrhythmias. Turn to page 42, enter an "x" in the "Dependent Positive" column corresponding to this question, then proceed to the following section on geographical characteristics.

Geographical Characteristics

As referred to in Appendix B, no communications system, including telemetry, can guarantee 100 per cent coverage. The possibility exists of encountering areas where transmission and/or reception is not possible (17, p. 12).

Although the geographical characteristics of your area are not likely to singularly prohibit the use of telemetry within your system, these characteristics may present some special problems in regard to the reliable operation of telemetry. For example, foliage, hills, mountains, building density (number of buildings), building material, and distance to be covered are among the factors which can affect the reliability of telemetry. High humidity may markedly reduce the effective range of telemetry transmission at the 460 MHz frequencies allocated for telemetry. In addition, artifacts in the EKG transmission may be produced by such things as reflection of the radio signals from nearby hills (29, p. 1278), crossing over railroad tracks (15, p. 9), and patient movement during transmission (17, p. 21).

For the reasons mentioned above, it is important for you to consider the special geographical characteristics of your EMS region, and the effect that these characteristics may have upon the use of telemetry. If you are not sure if your system contains special geographical problems for the use of telemetry, a study of these geographical limitations could prove to be worthwhile. An independent technical consultant or communications industry representatives should be able to tell what, if any, geographical limitations exist for your area.

Question 1: Are there special problems anticipated in the utilization of telemetry due to the geographical characteristics of your area?

No: Although this answer indicates that you probably could expect little difficulty in implementing a telemetry system, from an operational standpoint, it is not cause for using telemetry. Turn to page 42 and enter an "x" in the "Dependent Positive" column corresponding to this question. Also indicate that Question 2 is not applicable to you by entering "NA" in each possible answer space corresponding to Question 2 in the Geographical Characteristics category, then proceed to the following section on population characteristics on page 42.

Yes: Turn to page 42, enter an "x" in the "Dependent Negative" column which corresponds to this question, and return to Question 2.

Question 2: If special geographical problems exist, do they prohibit the utilization of telemetry?

Yes: This is an unlikely answer for most EMS systems, provided enough funds are available to overcome any geographical problems. However, this answer could indicate unique problems which are not representative of every system or area (e.g., the building density of New York City), or could perhaps be indicative of a system which cannot afford the price of overcoming the geographical limitations. For example, distances to be covered can be expanded through the use of repeaters*, but such methods or devices usually increase the cost of a system. If prohibitive geographical problems exist, you should consider the use of well-trained EMTs to treat cardiac emergencies without telemetry, if the law allows you this flexibility in your area. You may wish to continue with the Guide, however, rather than base your decision upon this question alone. If so, turn to page 42 , enter an "x" in the

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*Repeaters can be defined as radio transmitting and receiving systems which are capable of "repeating" radio signals, thus increasing the range of the signals.

"Negative" column corresponding to this question, and proceed with the Population Characteristics section which follows.

No: This is the likely answer for most systems, because the communications industry has progressed to the point that, given enough time and money, most geographical problems can be overcome so that the reliability of the telemetry system is adequate. However, to overcome these problems usually requires additional equipment and funds. Turn to page 42, enter an "x" in the "Dependent Positive" column corresponding to this question, and proceed with the following section on population characteristics.

Population Characteristics

In a previous section of the Guide, you estimated the potential demand for telemetry in your EMS system, based upon one of two alternative methods. These methods differed only in regard to the capabilities of the EMT. In both Method I and Method II, the population factor was considered as a singular constant. However, there are at least two primary aspects regarding population characteristics which you should analyze prior to making any judgments regarding the use of telemetry in your system.

One such aspect is the consideration of the total number of people (population size) within the region your EMS system is to serve. This aspect was discussed briefly in the Potential Demand for Telemetry section. At that point in the Guide, the examination of the relationship of population size to the anticipated utilization was sufficient to enable you to make a preliminary decision regarding the use of telemetry. A second aspect of population characteristics which should be addressed is the location of the population to be served by your system. Each of these aspects is discussed in the following subsections.

Population Size

Although population size was discussed to some extent in the previous determination of the potential demand for telemetry in your system, it is addressed once more for re-emphasis, and for the additional purpose of adhering to the Guide format.

Question 1: What is the approximate potential demand per day for telemetry in your EMS system?

Answer: From Method I, page 20, or from Method II, page 21, find the potential demand for telemetry figure previously determined by you. After locating this previously determined figure, turn to page 42 and enter the same figure in the space provided adjacent to Question 1 in the Population Characteristics category of questions. After entering the figure in the space provided, continue with Question 2 below.

Question 2: Is the approximate potential demand for telemetry in your system large enough, in your opinion, to justify the use of telemetry?

No: As referred to earlier, there may be extenuating circumstances which justify the utilization of telemetry, even though its use will be limited. Turn to page 42, enter an "x" in the "Dependent Negative" column corresponding to this question, then proceed to the subsection on population location immediately following the narrative accompanying the "Yes" answer to this question.

Yes: This answer indicates only that, from a statistical standpoint, there may be a sufficient demand for telemetry to justify its use. It should be re-emphasized that, as shown in the section on potential demand, there may be extenuating circumstances which influence the demand upon telemetry within your system. Turn to page 42 and enter an "x" in the "Dependent Positive" column which corresponds to this question. Then proceed to the subsection on population location immediately following this answer.

Population Location

The location of the majority of the population (hence, the greatest potential demand) within your EMS system may have some effect upon your decision regarding the use of telemetry. An anlysis of this possibility is presented in the following paragraphs.

A predominantly rural area, because of a smaller population, will not contain as many potential users of telemetry as will an urban area. However, a rural EMS system, because of the location of the people it serves, will involve ambulance trips of greater distance and longer duration than those in an urban system. These longer trips may warrant the use of telemetry, even though such use may prove to be infrequent. Advanced Technology Systems Inc., in an study of emergency medical communications, advises, "Due to the long distances involved [in rural areas], continuous radio interchange of medical information is a necessity between emergency care facilities and responding emergency vehicles. Bio-medical telemetry transmissions over long distances are indicated." (2 , p. III-4)

Since the locations of the majority of the population in your EMS system may have a significant influence upon your decision regarding the use of telemetry, it is appropriate to examine the population location of rural and urban systems separately. If your EMS system is to serve a predominantly rural area, proceed to Question 3 below. If your system is to serve an urban population, Question 3 is not applicable to you. Therefore, turn to page 43 and enter "NA" in each answer space corresponding to Question 3 in the Population Characteristics category of questions, since you are to skip Question 3. After you have entered "NA" in each space corresponding to Question 3, proceed to the discussion immediately following the narrative which accompanies the "No" answer to Question 3.

Question 3: Does the medical community within your rural EMS system feel that the use of telemetry is justified, due to the anticipated lengthy duration of ambulance trips (from emergency site to hospital)?

Yes: If other factors (e.g., legal aspects, reliability, etc). are in accord with this opinion, you may want to consider implementing a telemetry system. Turn to page 43 and enter an "x" in the "Dependent Positive" column which corresponds to this question. Also enter the letters "NA" in each answer space for Question 4, since you will be skipping that question. After entering an "x" in the appropriate space for Question 3 and "NA" in each answer space for Question 4, proceed to the Summary section on page 44.

No: If telemetry is not justified (or required) in the opinion of the medical community, then its use will serve little purpose. However, you should proceed with the Guide. Turn to page 43 and enter an "x" in the "Dependent Negative" column which corresponds to this question. Also enter the letters "NA" in each answer space for Question 4, since that question is not applicable to a rural EMS system. After entering an "x" in the appropriate space for Question 3 and "NA" in each answer space for Question 4, proceed to the "Summary" section on page 44.

An EMS system serving a predominantly urban population has a greater potential demand for the use of telemetry than does a rural system, because of the sheer numbers of people involved. Although this larger potential demand may suggest the use of telemetry, the urban EMS system may have some qualities which discourage the use of telemetry, even though its potential utilization might be high. For example, as mentioned previously in reciprocal fashion, ambulance trips within an urban system will generally be of lesser distance and shorter duration than those in a rural system. The limited duration of ambulance trips within an urban system may make the use of telemetry impractical. If ambulance trips (from emergency scene to hospital) are of only three or four minutes duration, there may not be adequate time for the EMT to connect the patient to the telemetry equipment, transmit an EKG, receive instructions, and respond as directed before reaching the hospital.

Question 4: Within your urban EMS system, are enough ambulance trips (from emergency scene to hospital) of sufficient duration to warrant the use of telemetry?

Yes: Turn to page 43 and entern an "x" in the "Dependent Positive" column which corresponds to this question. Then proceed to the Summary section of the Guide on page 44.

No: Turn to page 43 and enter an "x" in the "Dependent Negative" column which corresponds to this question. Then proceed to the Summary section of the Guide on page 44.

TABULATION PAGE*

	Positive (P)	Dependent Positive (DP)	Negative (N)	Dependent Negative (DN)
<u>Legal Aspects</u>				
1. Within your EMS system, are EMTs authorized to administer drugs and defibrillation to victims of a heart attack?		____**	____**	
(DP) and (N) Turn to page 25 and proceed with Question 2.				
2. If authorized to administer drugs and to defibrillate, must such actions be dependent upon the utilization of telemetry?	____	____		____
(P), (DP), and (DN) Turn to page 25 to the discussion following the "Usually" answer narrative.				
<u>Physician Attitude</u>				
1. Do physicians within your EMS system prefer the utilization of telemetry as a prerequisite to the treatment (defibrillation and drug administration) of coronary cases by the EMT?		____		____
(DP) Turn to page 27 and proceed with Question 2.				
(DN) Enter "NA" in each answer space for Question 3 in this category. Then turn to the "Recieving Personnel" section on page 30 and continue with the Guide.				
2. If physicians prefer the use of telemetry in some cardiac emergencies, what are the specific types of cardiac emergencies, and with what frequency does each occur?	(See list on page 27, if applicable.)			

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*An explanation of the Tabulation Page column headings and various answers is presented in the following Summary section. The Tabulation Page should be completed as instructed before proceeding to the Summary section.

**Instructions for proceeding with the Guide are stated directly below each question.

TABULATION PAGE
(Continued)

	Positive	Dependent Positive	Negative	Dependent Negative
3. Do the cardiac emergencies which you listed in response to Question 2 [on page 27] occur frequently enough to warrant the use of telemetry?		____		____
(DP) Turn to the "Receiving Personnel" section on page 30 and proceed.				
(DN) Turn to the "Receiving Personnel" section on page 30 and proceed.				
<u>Receiving Personnel</u>				
1. Are personnel immediately available on a twenty-four hour basis within your system to read telemetered EKGs and issue directions regarding treatment to the EMT?		____		____
(DP) Enter "NA" in each answer space for Question 2 in this category. Then turn to page 32 and proceed with the "Transmitting Personnel" section.				
(DN) Turn to page 32 and proceed with Question 2.				
2. If not immediately available on a twenty-four hour-a-day basis, are these personnel available a sufficient amount of time, in your opinion, to justify the use of telemetry?		____		____
(DP) and (DN) Turn to the "Transmitting Personnel" section on page 32 and proceed.				
<u>Transmitting Personnel</u>				
1. Are EMTs in your system adequately trained in the treatment of life-threatening arrhythmias?		____	____	
(DP) Turn to page 33 and proceed with Question 2.				
(N) Turn to page 33 and proceed with Question 2 <u>only</u> if you envision an affirmative response to this question within the near future.				

TABULATION PAGE
(Continued)

	Positive	Dependent Positive	Negative	Dependent Negative
2. Are EMTs in your system adequately trained in the detection and recognition of life-threatening arrhythmias?		____		____

(DP) and (DN) Turn to the "Geographical Characteristics" section on page 34 and continue with the Guide.

Geographical Characteristics

	Positive	Dependent Positive	Negative	Dependent Negative
1. Are there special problems anticipated in the utilization of telemetry due to the geographical characteristics of your area?		____		____

(DP) Enter "NA" in each answer space for Question 2 in this category. Then turn to the "Population Characteristics" section on page 36 and proceed with the Guide.

(DN) Turn to page 35 and continue with Question 2.

	Positive	Dependent Positive	Negative	Dependent Negative
2. If special geographical problems exist, do they prohibit the utilization of telemetry?		____	____	

(DP) Turn to page 36 and proceed with the section on population characteristics.

(N) Turn to page 36 and proceed with the section on population characteristics if you desire additional information.

Population Characteristics

1. What is the approximate potential demand per day for telemetry in your EMS system? (Potential Demand = ________)

	Positive	Dependent Positive	Negative	Dependent Negative
2. Is the approximate potential demand for telemetry in your system large enough, in your opinion, to justify the use of telemetry?		____		____

(DP) and (DN) Turn to page 37 and proceed with the "Population Location" subsection.

TABULATION PAGE
(Continued)

	Positive	Dependent Positive	Negative	Dependent Negative
3. Does the medical community within your rural EMS system feel that the use of telemetry is justified, due to the anticipated lengthy duration of ambulance trips (from emergency site to hospital)?		____		____
(DP) and (DN) Enter "NA" in each answer space for Question 4 in this category. Then proceed with the "Summary" section on page 44.				
4. Within your urban EMS system, are enough ambulance trips (from emergency scene to hospital) of sufficient duration to warrant the use of telemetry?		____		____
(DP) and (DN) Enter "NA" in each answer space for the preceding Question 3. Then proceed to the "Summary" section of the Guide on the following page.				

SUMMARY

This section of the Guide provides an explanation of the column headings on the preceding tabulation pages, as well as the rationalization for placing certain answers in one column rather than in another. Also included is a discussion of the decision-making process in respect to the use of telemetry in your EMS system. In addition, various concluding remarks pertaining to those who have responded either negatively or positively to the question of telemetry utilization are presented in this section.

Explanation of Tabulation Page

The column headings for the appropriate answers on the preceding tabulation pages are: (1) Positive, (2) Dependent Positive, (3) Negative, and (4) Dependent Negative. Each column heading is designated so as to indicate, or suggest, varying degrees of the feasibility of using telemetry in your EMS system. The headings for each of the columns is defined as follows:

1. Positive - Answers in this column are strongly suggestive that telemetry be used in order to achieve an effective level of emergency coronary care.
2. Dependent Positive - Individual answers in this column are mildly suggestive that telemetry be used, but a single answer of this type is not sufficient cause to use telemetry. However, several "Dependent Positive" answers, when combined, may indicate that telemetry should be used in your system.
3. Negative - A single answer in this column either prohibits the use of telemetry or makes its use inadvisable for various reasons.
4. Dependent Negative - Individual answers in this column are mildly suggestive that telemetry not be used, but a single answer of this type is not sufficient reason to avoid its use. However, several "Dependent Negative" answers, when combined, may indicate that the use of telemetry in your system is undesirable or unnecessary.

There may be several reasons for placing an "x" which corresponds to a "Yes", "Usually", or "No" answer in one of the four column headings defined above. However, the existence of a single reason is usually sufficient justification for considering an answer to be a "Dependent Positive" factor, for example, rather than one of the other three types. Several of these reasons were previously implied or mentioned in the discussion which accompanied various answers within different sections of the Guide. In any event, the justification for placing an answer in a specific column should be readily apparent, with the possible exception of the answers below, which are accompanied by brief explanations for their positions. [Before reading the explanation, you should refer to the answer and corresponding question on the page(s) noted in parentheses.]

a. The "Yes" answer in the "Dependent Positive" column for Question 1, Legal Aspects (page 23). This answer is arbitrarily recorded in the "Dependent Positive" column, even though the significance of this answer could perhaps be interpreted as a "Dependent Negative" factor. However, it is placed in the "Dependent Positive" column becase the authorization of the EMT to administer drugs and defibrillate may make the use of telemetry a feasible possibility. (Without this authorization, telemetry would be of limited use.)

b. The "Yes" answer in the "Dependent Positive" column for Question 1, Transmitting Personnel (page 33). As with the answer above, this response is arbitrarily recorded in the "Dependent Positive" column. Without adequate EMT training in the treatment of life-threatening arrhythmias, telemetry will be of little use. Hence, an affirmative response indicates that the use of telemetry in your system may be feasible, depending upon other factors.

c. The "No" answer in the "Dependent Positive" column for Question 2, Transmitting Personnel (pages 33-34). This response is recorded in the "Dependent Positive" column rather than in the "Positive" column because your decision to use telemetry may depend upon the alternative approach you choose to take (i.e., the use of telemetry or the implementation of an EMT training program).

Decision-Making Process

The significance of each entry, especially the entries in the "Dependent" columns, in the tabulation pages may vary from system to system (i.e., an "x" in one column does not necessarily equal in importance another "x" in the same column). Hence, the decision-making process, in respect to the utilization of telemetry in your system, may require a subjective analysis of the significance of various entries in the tabulation pages.

To reach your decision, you should analyze the importance of each answer to your EMS system. In this process of analysis, each answer should be evaluated in terms of its relationship to other answers.

Any "Negative" answer in the preceding tabulation pages indicates that you probably should not attempt to implement telemetry in your EMS system. Conversely, a "Positive" answer indicates that you probably should use telemetry. If you answered any of the questions with either a "Positive" or "Negative" answer, your telemetry decision may be based upon such an answer alone.

However, the majority of your answers are probably in either the "Dependent Positive" or "Dependent Negative" columns. If so, it is necessary to evaluate each answer as described above (i.e., in relationship to other answers). This process of evaluation may involve analyzing several combinations of two or more answers. The analysis of any one combination may appear to be sufficient to determine whether telemetry is necessary or feasible for your EMS system. However, the importance of analyzing several combinations of answers and determining which combination has the most significance to your system cannot be over-stressed. For example, a combination of "Dependent Positive" answers in Questions 1, 2, and 2 in the categories of Legal Aspects, Transmitting Personnel, and Population Characteristics, respectively, suggests that telemetry should probably be used. However, a combination of a "Dependent Negative" answer to Question 2, Receiving Personnel, and with the three "Dependent Positive" answers above, suggests that you will not use telemetry much, even though it may be needed in order to achieve an effective level of emergency coronary care.

When you have determined and analyzed the significance of each answer, and of various combinations of answers, which you entered on the tabulation pages, you should have a sound basis upon which to make your telemetry decision. You should proceed to conduct such a process of analysis and evaluation, paying particular attention to any "Positive" or "Negative" answers, and to any "Dependent Positive" or "Dependent Negative" answers to Question 1, Legal Aspects; Question 1, Physician Attitude; Question 1, Receiving Personnel; Question 2, Transmitting Personnel; and Question 2, Population Characteristics. After you have completed this activity and made a decision regarding the use of telemetry in your system, continue with the "Concluding Remarks" section of the Guide which follows.

Concluding Remarks

If you have determined that it is desirable and/or necessary for you to use telemetry in order to achieve an effective level of emergency coronary care within your EMS system, you should consult appropriate industry representatives and communications specialists in your area for assistance in the design and implementation of a telemetry system. On the other hand, if you have decided against the use of telemetry, you will have to rely upon various other components (primarily the EMT) of your EMS system to achieve the desired level of emergency coronary care.

If you have concluded that the use of telemetry is not necessary for your EMS system, but is a feasible and/or desirable means for attempting to achieve an effective level of emergency coronary care, you have perhaps the best of both worlds. In any event, it is perhaps best to consider telemetry as a valuable stepping stone to reaching the goal of the EMT's recognizing electrocardiographic abnormalities through his own skills and capabilities, and carrying out the appropriate treatment of an emergency cardiac patient at the emergency scene and en route to the hospital.

Appendix A: Various Systems Design Configurations

This appendix describes some of the variations in telemetry systems design configurations. An understanding of these variations should provide you with additional insight into the complexities of the telemetry issue.

Intermittent and Continuous Telemetry

There are basically two types of telemetry - continuous and intermittent. As indicated by their names, data transmitted in an intermittent telemetry system is transmitted for a brief period of time, then terminated, and re-transmitted if necessary; continuous telemetry involves continuous monitoring and transmission of data, without interruption, for as long as necessary.

If telemetry is to be used within an EMS system, the decision to use the continuous or the intermittent variation should be made only after careful consideration of the expertise of the EMT within the EMS system. However, some general statements on behalf of each type can be presented without regard to the expertise of the EMT. These statements are presented below, in addition to a brief discussion of the required ambulance equippage for each variation.

Continuous. In comments regarding FCC Docket #19261, Dr. Gary J. Anderson of Indianapolis, Indiana states, "If the electrocardiogram is to be monitored it should be monitored following the concepts established by the Coronary Care Unit, which mandates that a monitoring system be continuous. Interruption of the telemetered electrocardiographic data places the patient in the potential risk of developing a paroxysmal [sudden] or intermittent arrhythmia, which may be life threatening and undetected." (1) Dr. Anderson points out that it is accepted practice to monitor a patient continuously once he has been admitted to the CCU; for that reason, it is ". . . seemingly compromising, and without logic, to monitor the same patient intermittently prior to the time he arrives at the hospital." (7) Dr. Anderson et al. add that disturbances of rhythm may be transient, and asystole or ventricular fibrillation may appear with little forewarning (6 , p. 644).

A continuous telemetry system requires an exclusive frequency in order to insure freedom from interruption (6, p. 644). Although this "freedom-from-interruption" characteristic of continuous telemetry is a necessary quality, it is a quality that may prove to be undesirable when other factors are considered. For example, if several ambulances within an EMS system are to have the capability for continuous telemetry, each ambulance must have equipment which operates on several frequencies to avoid delays. Several ambulances telemetering on different frequencies would require that the receiving station(s) be capable of receiving as many frequencies as the total number of ambulances using telemetry. This capability requires additional equipment and probably results in additional costs. Furthermore, obtaining the exclusive use of several different frequencies may prove to be difficult.

An additional argument for the use of continuous telemetry suggested by Anderson et al. is that it relieves the ambulance personnel of decision-making responsibility (6 , p. 645). However, Dr. Anderson states that the well-trained EMT can monitor continuously as well as hospital-based personnel (7).

If continuous telemetry is to be used within an EMS system, then the ambulances which are to have telemetry capability must be equipped with one of the following configurations:

a. "To transmit on both frequencies of a frequency pair allocated for telemetry, e.g., 463.000 and 468.000 MHz. This would require that the ambulance be equipped with two UHF transmitters and one UHF receiver. Telemetry would be transmitted to the fixed terminal on the mobile only frequency, 468.000 MHz, and voice data interchange between the fixed terminal and the ambulance would be transmitted on the base and mobile frequency 463.000 MHz." (24, p. 31) [Frequency pairs allocated for telemetry are discussed in Appendix D .]

b. "To multiplex (combine) both telemetry and voice data on the mobile only frequency of the telemetry frequencv pair (468.000 MHz.) and receive voice data from the fixed terminal on the base and mobile frequency of the pair (463.000 MHz.). In addition, the fixed terminal must be equipped with demultiplexing equipment for each available channel to separate voice and telemetered data." (24, p. 31)

c. "To transmit telemetry data on the mobile frequency of the telemetry frequency pair, and transmit ambulance voice data on one of the VHF frequencies 155.340 MHz for example." (24, p. 31)

Intermittent. This variation in telemetry system design may utilize a single-channel system which may necessitate the use of a given frequency for both EKG transmission and voice communication. This limitation can be overcome, however, by employing a multi-channel radio system. Ambulance personnel using intermittent telemetry, while sharing a UHF telemetry frequency with other vehicles, may communicate with the receiving station on a VHF frequency. Intermittent telemetry may allow for greater flexibility than would a system using continuous telemetry, since more than one ambulance can use the same frequency for telemetry.

An intermittent telemetry system requires that the ambulance be equipped with a UHF transceiver configured to receive on the base station frequency of the frequency pair allocated for telemetry and to transmit of the mobile frequency (24, p. 31).

Channelization

The number of channels, or frequencies, which are required by an EMS telemetry system depends upon the probability that there will be simultaneous need for telemetry transmission and/or reception in the same area (2 , p. II-2). In a study (2) for the FCC on emergency medical communications system requirements, Advanced Technology Systems, Inc. indicated that multiple channels should be available for both rural and urban EMS systems, and that the opportunity should exist for full-time use when required. Within an urban system where the number of emergencies is high, multiple channels for both receiving and transmitting are required to meet multiple simultaneous requirements. Rural systems, while not having as many emergencies as urban systems, have special characteristics which indicate the need for multiple channels, also. The need for achieving wide-area coverage in rural areas dictates the use of several selected sites capable of receiving and transmitting within the rural system. To permit simultaneous use of adjacent sites, multiple channels will be required to avoid interference between two or more sites which are near each other. Consequently, the number of channels required to avoid interference with neighboring stations will approach the number of channels required in an urban system to handle a concentration of events, even though the number of channels required to provide simultaneous coverage of emergencies in a rural area may be small. (2, p. II-2)

If you anticipate the use of telemetry in your EMS system, you should seek the guidance of an appropriate radio communications industry representative or radio communications consultant in your area to determine the number of channels required to meet your system's needs and to avoid an unacceptable amount of interference.

Single vs. Multiple Receiving Stations

The location and number of telemetry receiving stations within an EMS system may appear to be primarily dependent upon the anticipated demand on the system. It must be remembered, however, that a single receiving station is capable of handling simultaneous requirements for telemetry through the use of multiple channels. Of course, extreme situations of frequent, simultaneous use of multiple channels for the receipt of telemetered information in a single receiving station should be avoided.

The existence of more than one receiving station within a system may result in the loss of standard operating procedures and the intervention of personal preferences of ambulance personnel (7). The utilization of a single receiving station, however, enhances the establishment of standard operating procedures between the EMT and the receiving station personnel, and lessens the likelihood of personal preference intervention.

As for anticipated demand upon a telemetry system, Jacksonville, Florida has found that it is not necessary to have receiving stations for telemetry at every hospital within the system, since one hospital can handle the telemetry reception for the entire city (27). [Additional information regarding the demand for telemetry in Jacksonville is furnished in Appendix C.]

Whether a single station or multiple receiving stations are used within an EMS system, it may be desirable for ambulance personnel to furnish ED personnel with a written record of the patient's heart activity which occurred during the duration of the ambulance trip. This may be especially beneficial in those instances when a cardiac patient is delivered for treatment to a hospital other than the receiving hospital. In any event, such a written record can be provided through the use of a strip chart recorder on board the ambulance.

Appendix B: Some Systems Design Considerations

The subjects discussed in this appendix are factors which may influence to some extent the systems design configuration which is appropriate for the telemetry component of your EMS system. However, the factors discussed in this appendix are probably not of primary importance to your telemetry decision; consequently, they are not included in the Primary Factors for Consideration section of the Guide.

Frequency Utilization and Availabilty--UHF and VHF

Within the "radio waves" portion of the electromagnetic frequency spectrum, there are eight designated frequency bands (24, p. 17). Table 5 lists these band designations and the corresponding range of frequencies allocated for each by the FCC (24, p. 17).

Primarily, only two of the radio bands shown in Table 5 are used for emergency medical communications. The FCC has set aside VHF band assignments for general emergency medical radio communications, and UHF band assignments for telemetry systems. For all intents and purposes, the FCC restricts the operation of telemetry in any frequencies other than those in the UHF band. (The primary exception to this restriction is those systems which were previously licensed to telemeter on the VHF band. These systems will convert to the UHF band when required by the FCC.) (28) However, the importance of VHF communications to a telemetry system should not be overlooked. As mentioned previously, an effective telemetry system must possess the capability for voice data interchange. These voice communications can be conducted on certain VHF frequencies.

The FCC has allocated seven frequency pairs in the UHF band for use by telemetry systems. (A discussion of the specific, available frequency pairs is presented as Appendix D.) These seven frequency pairs are within the 460-470 MHz range. Communications within this 460 MHz range have several advantages when compared to VHF communications. Some of these advantages are: a low noise level, superior penetration through solid structures, such as buildings, and freedom from "skip" interference, which is caused by unintentional and unavoidable reception of signals

TABLE 5

RADIO SPECTRUM FREQUENCY BANDS

Band Designations	Frequency Ranges	
Very Low Frequency (VLF)	3-30 kc/sec	(kHz)*
Low Frequency (LF)	30-300 kc/sec	(kHz)
Medium Frequency (MF)	300-3,000 kc/sec	(kHz)
High Frequency (HF)	3-30 Mc/sec	(MHz)
Very High Frequency (VHF)	30-300 Mc/sec	(MHz)
Ultra High Frequency (UHF)	300-3,000 Mc/sec	(MHz)
Super High Frequency (SHF)	3-30 Gc/sec	(GHz)
Extremely High Frequency (EHF)	30-300 Gc/sec 300-3,000 Gc/sec or 3 Tc/sec	(GHz) (GHz) (THz)

SOURCE: U. S. Department of Health, Education, and Welfare, Emergency Medical Services Communications Systems, Rockville, Maryland, August 1972, p. 17.

*Abbreviations generally used are:

Hertz (Hz)	=	cycles/second (C/sec)
Kilo (k)	=	1,000
Mega (M)	=	1,000,000
Giga (G)	=	1,000,000,000
Tera (T)	=	1,000,000,000,000

that are transmitted from a point located at a great distance from the reception point (25, p. 14, 24, p. 18).

Conflicting the above advantages of the UHF band for telemetry use are the 460 MHz frequencies' shorter range than the VHF frequencies, and a greater degree of energy absorption by high humidity, trees and foliage, which adversely affects transmission reliability (25, p. 14, 24, p. 18).

Although only those UHF frequencies mentioned above, and discussed in greater detail in Appendix D, are available for telemetry purposes, the printed Rules and Regulations of the FCC are continually updated as changes are made. Therefore, prior to making any definite plans for the inclusion of telemetry in an EMS system, a copy of these regulations should be reviewed, and communications professionals should be consulted to assist in the interpretation of these FCC regulations.*

Licenses for the utilization of telemetry frequencies are assigned by the FCC. The FCC also determines what requirements the applicants must meet. You should consult the district office of the FCC in your area to determine precisely what these requirements are. It should be noted that the preparation of an application for a telemetry license, review of the application by the FCC, and granting of the license usually require a few months, and should be planned for accordingly.

Reliabilty

Few, if any, telemetry systems will be 100% reliable--i.e., experience no transmission or reception failure. Unfortunately, you cannot accurately determine the reliability of a system until some real-life experiences can be analyzed, even though the system may have been designed to yield an acceptable level of reliability.

As a case in point, the City of Miami Fire Department Rescue Service, over a twenty-four month, initial experimental period, experienced an overall communications reliability factor of 80 per cent (134 satisfactory

*Copies of the Rules and Regulations can be purchased from the Superintendent of Documents, Government Printing Office, Bookstore, 8th Street and North, Washington, D. C. (26,p. 15).

completions out of 169 attempts). Complete transmission failure occurred in 23 cases, with causes due to "shielding' (buildings, rain), electrical interference, positional problems, etc. (18, p. 335) [New equipment to improve reliability was reported as being installed after the experimental period. It should be noted, however, that the state of the art has progressed considerably since Miami's initial efforts in telemetry utilization were attempted, and an 80 per cent reliability factor is probably unrealistically low for present systems.]

Since a telemetry system, or any communications system, will be unreliable at least part of the time, it may be worthwhile for you to anticipate the significance of these unreliable periods. Using the estimate of 35 emergency calls per 1000 population per annum (23, p. 31), a city of 500,000 population could expect approximately 17,500 emergency calls annually. Based upon the experience over a six-month sample period in Jacksonville, approximately 14 per cent (2450) of the 17,500 emergency calls will be cardiac-related, and perhaps could benefit from the utilization of telemetry. (See Appendix C .) Using the figure of 80 per cent reliability from the preceding paragraph, 20 per cent (490) of the 2450 cardiac emergencies would be affected by unreliable telemetry over a period of one year.

To carry the illustration a step further, 15 per cent of the patients successfully monitored in the above-mentioned Miami system experienced ventricular fibrillation, a condition requiring immediate treatment (18, p. 332). Based upon this 15 per cent figure, 73 of the 490 patients cited in the preceding paragraph would have suffered ventricular fibrillation. Unless the EMT can defibrillate these patients in the absence of telemetry, the patients will not receive appropriate treatment, and, in this example, 73 might have died as a result.

In the event that you decide to use telemetry in your EMS system, you should plan a course of action to be followed by the EMT when telemetry transmission fails, if the EMT is legally allowed to follow such a course of action. The EMS system in Jacksonville provides for failures in transmission by having advance written orders for the EMT to follow if unable to establish communications with the receiving hospital (27). Captain John M. Waters, Director, Department of Public Safety in Jacksonville, points out that in cases when transmission between the ambulance and the hospital is not possible, the EMT must be well-trained in EKG interpretation, so that he can give an accurate description of what he observes to the receiving physician (9, p. 19).

Cost Considerations

The costs associated with telemetry utilization may appear to be a significant factor in determining the possible use of telemetry within your EMS system. Indeed, the cost of EMS components (e.g., training, communications, vehicles) is certainly an item with which conscientious planners are concerned, and costs may influence to some extent the decision to use telemetry.

As described in Appendix A , the use of telemetry requires that an ambulance be furnished with equipment capable of transmitting on one or more of the UHF frequencies allocated for telemetry. This required equipment may be in addition to VHF equipment which is in an ambulance for the purpose of voice communications between the ambulance and the hospital or dispatch center. In such an instance, the required UHF telemetry equipment would represent a minor additional expense to the communications system equipment. However, this additional expense for equipment should not be interpreted as representing an increase in cost to the total EMS system.

In fact, alternative methods of achieving an effective level of emergency coronary care may be more expensive in the long run than a method which utilizes telemetry. For example, a system which does not have telemetry may have to rely on the training and expertise of the EMT and the supervision given the EMT by voice communications between the EMT and the hospital or physician in order to achieve an effective level of emergency coronary care. The additional training and skill (e.g., arrhythmia recognition) required by the EMT in this illustration may result in higher salaries being paid to the EMT in the system without telemetry than the EMT receivies in a system which uses telemetry. (As mentioned in the preceding subsection on reliability, however, EMTs should probably be trained to respond to cardiac emergencies in the event that telemetry transmission or reception fails; therefore, telemetry may prove to be an additional expense.)

Costs will fluctuate with different configurations of telemetry systems design. While it is beyond the scope of this Guide to elaborate on cost fluctuations, it can be stated that the fluctuations related to telemetry systems design will probably be relatively insignificant when compared to the total cost of the EMS system, or even one component of the EMS system. Fred B. Vogt, M.D., Professor of Electrical and Bio-Medical Engineering at the University of Texas at Austin, states that the cost of telemetry equipment for the total system is so small compared to manpower costs that it should not be a deterrent to the use of telemetry (9, p. 18). Therefore, cost should not be a major determining factor in consideration of systems design, or in the decision of using or not using telemetry.

Appendix C: Jacksonville EMS System Six-Month Sample Period Data*

During a six-month sample period, the Jacksonville, Florida EMS system responded to 12,000 calls. Approximately 50 per cent of these calls resulted in patient transportation by ambulance personnel (13 per cent transported on an emergency basis, and 37 per cent transported urgently, as distinguished from "emergency" transportation). Twenty-one per cent of the 12,000 calls were taken to the hospital by other means (not EMS vehicle) after triage by rescue personnel; 10 per cent received treatment at the scene and were not transported; 16 per cent required no care; and 3 per cent were dead at the scene. These results are presented in tabular form in Table 6.

TABLE 6

DISPOSITION OF JACKSONVILLE'S EMERGENCY CALLS DURING SIX-MONTH SAMPLE PERIOD

Emergency Calls	Number	Per Cent
Transported (Emergency)	1,560	13
Transported (Urgently)	4,440	37
Transported (Other Means)	2,520	21
Treated at Scene	1,200	10
No Treatment Required	1,920	16
Dead at Scene	360	3
Total	12,000	100

Of the 12,000 emergency calls, 14 per cent were reported as cardiac-related. However, only 876 (7.3 per cent) of these calls were found to involve acute cardiac patients. Of the 876 acute cardiac patients, 155 (18 per cent) were dead at the scene beyond any treatment; 106 (12 per

*Developed from a telephone conversation between Julian Pittman, HSRC, and Captain John M. Waters, Director, Department of Public Safety, Jacksonville, Florida, on November 5, 1973.

cent) died in the field after CPR was administered;* 51 (6 per cent) were viable at the scene (but later required CPR enroute) and were delivered to the hospital viable; 561 (64 per cent) were transported uneventfully, without resuscitation, but frequently with drugs, and nearly always with oxygen. The disposition of these acute cardiac patients is shown in tabular form in Table 7.

TABLE 7

DISPOSITION OF JACKSONVILLE'S ACUTE CARDIAC PATIENTS DURING SIX-MONTH SAMPLE PERIOD

Disposition	Number	Per Cent
Dead at Scene	155	18
Died in Field After CPR	106	12
Viable at Scene but Required CPR En Route	51	6
Transported Uneventfully	561	64
Total	876	100

*It should be noted that most of these 106 victims were "clinically dead", but CPR was administered anyway, since the exact time of death was unknown and resuscitation might have proved to be effective.

Appendix D : Frequencies Allocated for Telemetry Utilization

On March 29, 1972 the Federal Communications Commission released a Report and Order relating to Docket No. 19261 which had proposed changes in the rules regarding ambulance telemetry. This FCC ruling has made seven base-mobile frequency pairs in the 460 MHz band available for ambulance-to-hospital telemetry systems. These frequencies are summarized in Table 8 .

TABLE 8

AVAILABLE TELEMETRY FREQUENCIES

Base and Mobile	Service and Purpose	Mobile Only	Service and Purpose
460.525 460.550	Fire, Local Government, Special Emergency	465.525 465.550	Special Emergency for Dispatch-Response and Telemetry
463.000 463.025 463.050 463.075 463.100	Special Emergency for Telemetry-Related Voice and Portable Telemetry	468.000 468.025 468.050 468.075 468.100	Special Emergency for Telemetry and Telemetry-Related Voice

According to the above-mentioned Report and Order, the mobile frequencies are primarily assignable for telemetry transmissions, but supplemental voice operations related to the telemetry activity may also be conducted on mobile frequencies. The five base-designated frequencies 463.000 through 463.100 MHz are assignable for hospital-to-vehicle voice communications regarding the telemetry activity. They may also be used to accommodate the need for portable telemetering from patients before they can be placed into ambulances, by transmitting through ambulance radios to a hospital (portable to mobile/mobile-relay). The two base-designated frequencies 460.525 and 460.550 MHz are assignable only for central dispatching of ambulance telemetry systems under an area-wide communication plan for coordinated use of telemetry frequencies. They may be assigned in the Special Emergency and Local Government Radio Services, in addition to the Fire Radio Serivce, for this purpose. (No other 460 MHz frequency is available for dispatching ambulance telemetry systems.) The two mobile-only frequencies, 465.525 and 465.550 MHz, are also available under an area-wide communication plan for central dispatching which will also permit their use for telemetry when they are needed for the latter purpose. These communications plans may incorporate a single licensee dispatching multiple telemetry systems, or a group of licensees operating independent or shared telemetry systems, or both.

Further limitations relating to these frequencies are noted in Table 9 below, with an explanation of the designated limitations following.

TABLE 9

LIMITATIONS OF TELEMETRY FREQUENCIES

Frequency (MHz)	Class of Station(s) With Limitations*	Frequency (MHz)	Class of Station(s) With Limitations*
460.525	Base & Mobile (1), (2)	465.525	Mobile Only (1), (5)
460.550	Base & Mobile (1), (2)	465.550	Mobile Only (1), (5)
463.000	Base & Mobile (1), (3)	468.000	Mobile Only (1), (4), (6)
463.025	Base & Mobile (1), (3)	468.025	Mobile Only (1), (4), (6)
463.050	Base & Mobile (1), (3)	468.050	Mobile Only (1), (4), (6)
463.075	Base & Mobile (1), (3)	468.075	Mobile Only (1), (4), (6)
463.100	Base & Mobile (1), (3)	468.100	Mobile Only (1), (4), (6)

SOURCE: U. S. Department of Health, Education, and Welfare, Emergency Medical Services Communications Systems, Rockville, Maryland, August 1972, p. 24.

*Limitations are noted by numbers in parentheses and explained below.

1. "For two frequency systems, separation between base and mobile transmission frequencies is 5 MHz.

2. The frequency may be assigned (a) to dispatch ambulances and personnel operating bio-medical telemetry units under an area-wide radio communications plan; and (b) is available also for this purpose in the Fire and Local Government Radio Services.

3. This frequency is available for assignment to hospitals (institutions or establishments offering service, facilities, and beds for use beyond 24 hours in rendering medical treatment) for communication with medical care vehicles and personnel equipped with bio-medical telemetry capability. Use of this frequency is further authorized for telemetry or voice transmissions from a portable telemetering unit to an ambulance for automatic retransmission (mobile/relay) from a patient to a hospital or other medical care facility. When using telemetry emission, the continuous carrier mode of operation is authorized for this frequency.

4. This frequency is available for assignment to operating mobile bio-medical telemetry units in ambulances and other medical care vehicles, or when hand-carried by medical personnel. Telemetry transmission may be authorized. Voice transmission may also be authorized on a secondary basis when required for the telemetering activity. When using telemetry emission, the continuous carrier mode of operation is authorized for this frequency.

5. This frequency may be assigned primarily for mobile dispatch response by ambulance and personnel operating bio-medical telemetry units in this service under an area-wide radio communications plan involving central dispatching on the associate base-mobile frequency 460.525 or 460.550 MHz. When authorized for this dispatch response purpose, this frequency may be used on a secondary basis for the purposes and in the manner set forth in limitation (1), (4), and (6).

6. Mobile stations authorized to operate on this frequency may be used to extend the range of transmission between portable telemetering unts and hospitals or other medical care facilities. Each mobile station used for this purpose shall be so designed and installed that it will be activated only by means of a continuous tone device, the absence of which will deactivate the mobile transmitter. The continuous tone device is not required when the mobile station is equipped with a switch that must be activated to change the mobile unit to the automatic mode." (24, pp. 24 - 25)

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An Application of Management
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EMS System Data Requirements For Performance Evaluation

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EMS SYSTEM DATA REQUIREMENTS
FOR
PERFORMANCE EVALUATION

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FOREWORD

The present report describes an application of Management by Objectives (MBO) principles to the EMS system for the purpose of generating a set of data to be used for evaluating EMS system performance. The report was developed by the Health Systems Research Center (HSRC) to serve as an initial research effort toward the identification of appropriate performance measures for individual EMS systems. The data generated through this HSRC research are derived for an ideal and generalized EMS system to illustrate the goal-setting concepts of MBO in a manner in which most EMS system administrators can relate. The principles and methodology of this research project may serve as tools to aid in the performance evaluation of any EMS system.

This is the third of a series of outputs from an HSRC project supported since 1972 by a grant from the Bureau of Health Services Research. The project was originally conceived to be an attempt to develop an EMS simulation model. However, reviews of several working papers generated during the first year demonstrated to both the research team and the Bureau the need to redirect project objectives toward the subjects of ambulance location, telemetry, and data collection methodologies. Accordingly, the first of these subjects was addressed in a 133-page report, entitled Ambulance Placement Strategies for Emergency Medical Systems, which was released in January, 1974. The second topic was addressed in a 64-page report, entitled Telemetry Utilization for Emergency Medical Services Systems, which was released in June, 1974. The third subject, EMS system data collection, is the subject of the present document.

EMS has been a major area of interest within HSRC since early 1969 when the Metropolitan Atlanta Council for Health (MACHealth) established its Task Force on Emergency Health Services. The MACHealth Task Force was charged with the responsibility of identifying problems associated with the provision of emergency medical services in the metropolitan Atlanta area. HSRC participated actively on the Task Force, provided technical systems capabilities, and prepared a number of research, planning, and design proposals for and with MACHealth, which in 1972 became a division of the Atlanta Regional Commission (ARC).

HSRC was commissioned by ARC in 1972 to develop a comprehensive plan and systems design for an improved EMS system for metropolitan Atlanta. This work was done by HSRC under a contract with the Georgia Regional

Medical Program and was completed in March 1973. The resulting plan, described in a 566-page report, includes requirements for the number, types and geographical positioning of emergency vehicles; a recommendation for an organization for coordination, operation, and control of the EMS system components; a communications subsystem design; a comprehensive set of procedures for performing the dispatch and control function; recommendations for training EMS personnel; a scheme for evaluating EMS system performance; and recommendations for financing the EMS system.

The research described in the present document builds upon these and other EMS experiences, responds to interest expressed by the Bureau of Health Services Research, and partially fulfills an unmet need in the field of health planning.

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Principal Investigator

PREFACE

A review of data collected in many EMS systems indicates that many data of low utility are being collected for a variety of reasons. In addition, many systems do not collect data that are vitally needed to assess performance. The approach to data derivation presented in this report is believed to be relevant to most EMS systems and significantly reduces the potential for inappropriate data collection.

This report presents a unique approach to the determination of EMS system data requirements for performance evaluation. Management by Objectives (MBO) techniques are applied to the EMS system to determine, in a general and ideal manner, performance objectives for each function of the system. Data are derived from these objectives without regard for present or historical data derivation practices in existing EMS systems, and without regard for the feasibility or economics associated with data collection.

It should be pointed out that this report emphasizes the goal-setting procedures of MBO and is not an application of all aspects or phases of the MBO process. It should also be noted that the results of the MBO analysis have not been verified. The set of data presented herein is suggested as an ideal set of measures. Follow-up analysis and an application of the MBO technique in a real setting are recommended.

The authors wish to gratefully acknowledge the coordinative efforts of Mr. Julian V. Pittman (HSRC), and to thank Dr. Max Holland (Consultant) for assistance in the application of Management by Objectives to the EMS system.

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THE EMS SYSTEM AND SUBSYSTEMS

In order to apply the Management by Objectives (MBO) process to the EMS system, it is necessary to define the EMS system in precise terms. One method for defining the system is to identify the interactions of the various components which together constitute the EMS system. The definition can best be presented by grouping the various components together into subsystems.

Classical vs. Operational Subsystems

The configuration into which the system components are grouped to form subsystems is chosen so as to be conducive to an application of the analytical process to the EMS system. For developmental analysis, for instance, the EMS system has been defined in terms of the interactions of five system component groups or subystems, as listed below:

a. Communications Subsystem--All components necessary for the exchange of information in the EMS system.

b. Consumer Education Subsystem--All components related to improving the citizenry's interaction with the EMS system.

c. Training Subsystem--Those components dealing with the training of various EMS personnel, especially emergency medical technicians (EMT's).

d. Transporation Subsystem--All components necessary for the transportation of EMS resources to the victim and, if necessary, the conveyance of the victim to other medical resources.

e. Emergency Facilities Subsystem--Those components concerned with rendering emergency medical care at a fixed location. The "fixed location" is usually a hospital emergency department (ED) or a coronary care unit (CCU).

This manner of defining the EMS system is so well known that it may be considered classical. It has demonstrated its usefulness for those who are building or developing an EMS system.

There are definite problems associated with using the classical subsystem definitions as a framework for analyzing an operating EMS system. If, for example, the emergency facility subsystem is determined to be performing unsatisfactorily, the assumption that the causal factor will be found within the elements of the subsystem may be erroneous, because the performance of the communications and the training subsystems can significantly influence the performance of the emergency facilities subsystem. These problems arise when the classical EMS definition is used as an analytical fromework, because the subsystems are not defined to be mutually exclusive. It would be preferable for the purposes of operational analysis to have a set of subsystems defined so as to be mutually exclusive.

This research project is concerned with the analysis of operating EMS systems as opposed to developing EMS systems. The classical subsystem definitions appear to be of little use in this context. For the purposes of this project, it is desirable to define the overall EMS system in terms of operational or functional subystems. To accomplish this, one must determine how an EMS system functions from an operational and managerial viewpoint.

The EMS System in Operation

The description of how an EMS system functions has been the subject of some past work. The U. S. Department of Transportation's Highway Safety Program Manual (24) lists eight sequential functions for the operational EMS system:

a. Detecting the accident.

b. Reporting the accident.

c. Dispatching ambulances and public safety alerting emergency care facilities.

d. Driving ambulance(s) to the crash scene.

e. Rendering emergency care to the victims.

f. Extricating victims from the damaged vehicles, if required.

g. Transferring injured persons to the hospital and administering emergency care while en route.

h. Admitting the injured to the emergency department of the hospital.

The obvious shortcoming of this view of the operational EMS system is its orientation solely toward accidents, excluding the serious illness. Although the functions described may prove to be adequate, a more comprehensive presentation of the operational EMS system, in terms of all types of medical emergencies, is preferable.

One comprehensive EMS system description is presented in a Health Services and Mental Health Administration report entitled, Emergency Medical Services Communications System (23). This document describes EMS functions as follows:

a. Incident--The occurrence which generates the need for emergency services -- patient(s) with acute illness or injury.

b. Detection--The action which determines that the incident took place.

c. Notification--The action which informs the emergency resource control agency where and when the incident took place and the nature of the incident.

d. Dispatch--The act which orders emergency resources to the scene of the incident.

e. Closure--The process which transports emergency resources to the scene of the incident.

f. Action--The necessary acts which correct or alleviate conditions generated by the incident, including both immediate care and transport to a medical facility.

g. Return to Station--The return of all emergency resources to a state of readiness for a new cycle.

This comprehensive description of an EMS system is, for the most part, consistent with the accident-oriented version presented previously. Another substantiating description of the functioning EMS system is presented by Bordner et al. (5) in a study sponsored by the U.S. Department of Transportation. This report outlines the operating cycle of the EMS system as follows:

a. Accident or emergency illness

b. Detection

c. Notification

d. Dispatch

e. Closure

f. Triage

g. First-Aid

h. Transport

i. Stabilizing care

j. Delivery - return ETU (Emergency Transportation Unit)

k. Emergency medical care

l. Disposition

The Bordner version of the operational EMS system differs from those previously presented, in that it includes emergency medical care in a hospital (or other fixed facility) within the system. Although there has been, and continues to be, some disagreement on the terminal boundary of the EMS system, the inclusion of fixed facility care within the system is generally believed to be appropriate. Exits from the EMS system are often defined as admittance to a hosptial inpatient facility, discharge, or death. This view has been promoted by a declaration made at the historic (in terms of the current movement to improve EMS systems) Airlie Conference on Emergency Medical Services: "Such (emergency medical) services include first aid or emergency care at the scene of the accident or illness, transportation to a hospital while emergency care is being continued, and capable medical care in the emergency department of the hospital." (12)

The three versions presented to describe an operating EMS system seem to address the same functional sequence. Moreover, this sequence appears to be centered on the emergency victim.

EMS Subsystems

Using the available guidance as to how the EMS system actually operates, it is possible to define functional EMS subsystems that provide an appropriate analytical framework for analysis by management by objectives. The functional subsystems would necessarily require compatibility among the set to satisfy the requirements of the functional sequence described.

It is also desirable that the functional subsystems be defined so as to have three properties. First, the subsystems should be exhaustive so that the definition effectively contends with any needs of a patient in the EMS system. Secondly, the subsystem should be mutually exclusive from an operational viewpoint. The utility of this property for the purposes of operational analysis has been discussed. Thirdly, it is conceptually convenient if the subsystems are sequential with regard to the chronological sequence of events that occur as the victim is serviced by the system.

Simplicity is preferred. The use of a large number of subsystems is cumbersome for analytical purposes, and suggests the need for an intermediate level of subsystems between the detailed level defined in the preceding examples and the total EMS system itself.

Following these guidelines, the EMS system has been defined as five functional subsystems. These five subsystems, as diagramed in Figure 1 and discussed below, satisfy the requirements for the needed subsystem structure of the EMS system.

a. Entry Subsystem: This subsystem is composed of components that affect the receipt and transfer of information which describes each medical emergency from (and including) the perception of need to the EMS dispatch function.

b. Dispatch Subsystem: This subsystem is responsible for the analysis of the emergency request information and the subsequent initiation of a response to the emergency. Subsystem activities include the dispatch of personnel and equipment and the coordination and control of these resources.

c. Resource Transportation Subsystem: The components of the EMS system that affect the conveyance of the dispatched resources to the emergency scene are included in and define this subsystem. In addition, it is the responsibility of this subsystem to ensure that both vehicle and equipment are in good working order.

d. Field Care Subsystem: This subsystem is composed of those system components invloved in the management of an emergency at the medical incident scene, and if necessary, during the transportation of the victim/patient from the scene.

e. Facility Subsystem: Those components required to provide emergency medical care within a fixed facility, usually a hospital's ED or CCU, compose this final subsystem.

The Functional Subsystems vs. the Operating EMS System

It is important to demonstrate that the five functional subsystems (as previously defined) adequately describe the operating EMS system. A series of three tables is offered to show the interfacing between these five subsystems and the operating sequence illustrations of the EMS system previously presented.

Figure 1. Functionally-Defined EMS Subsystems

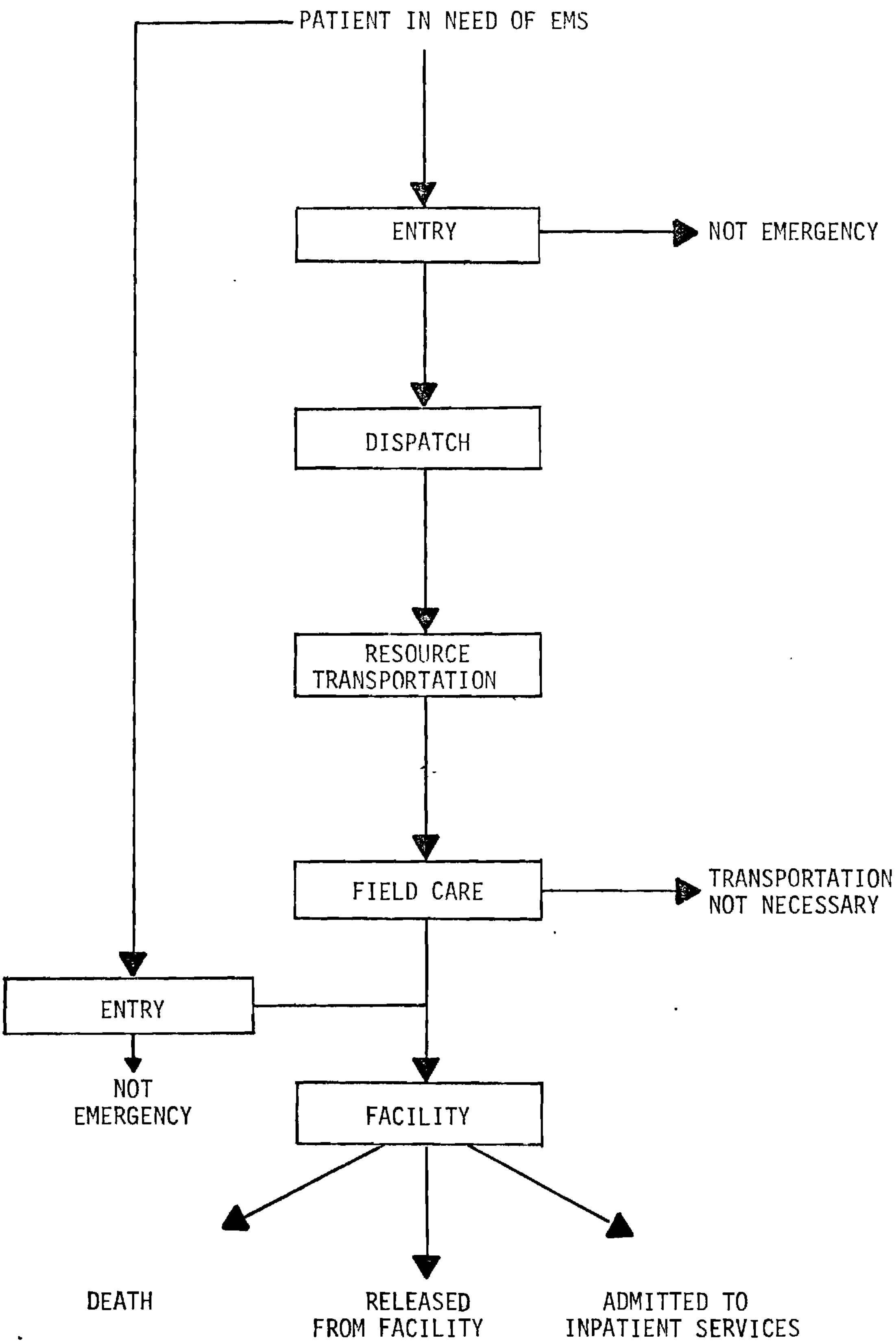


Table 1 presents the interface of the five subsystems and the operating EMS system as defined in the Highway Safety Program Manual (24). It should be noted that the five functional subystems defined comprehensively cover the functional sequence. The only point of conflict appears to be the fact that the facility subsystem, as defined, includes medical care in the emergency department or CCU, and the operating sequence as defined here does not. Justification for defining a facility subsystem has been previously stated. Function "h" in the functional sequence is a minor component of the facility subsystem. The other facility components are not listed in the example presented in Table 1.

TABLE 1

INTERFACE OF FUNCTIONAL SUBSYSTEMS WITH OPERATING EMS SYSTEMS AS DEFINED IN THE HIGHWAY SAFETY PROGRAM MANUAL

Functional Subsystems	EMS System in Operation
Entry Subsystem	a. Detecting the accident b. Reporting the accident
Dispatch Subsystem	c. Dispatching ambulances and public safety vehicles and alerting emergency care facilities.
Resource Transportation Subsystem	d. Driving ambulance(s) to the crash scene
Field Care Subsystem	e. Rendering emergency care to the victims f. Extricating victims from the damaged vehicle if required. g. Transferring injured persons to hospitals and administering emergency care while en route.
Facility Subsystem	h. Admitting the injured to the emergency department of the hospital.

The operating EMS system as defined in Emergency Medical Services Communications Systems (23) in interface with the five functional subsystems is shown in Table 2. Again, the five subsystems cover the operational sequence up to facility care. As in the discussion of Table 1, the inclusion of medical care at the fixed facility in the EMS system definition is recommended. The function "return to station" describes a resource transportation function.

TABLE 2

INTERFACE OF FUNCTIONAL SUBSYSTEMS WITH OPERATING EMS SYSTEM AS DEFINED IN EMERGENCY MEDICAL SERVICES COMMUNICATIONS SYSTEMS

Functional Subsystems	EMS System in Operation
	a. Incident
Entry Subsystem	b. Detection c. Notification
Dispatch Subsystem	d. Dispatch
Resource Tranportation Subsystem	e. Closure f. Return to Station
Field Care Subsystem	g. Action
Facility Subsystem	

The exclusion of the item "incident" in the five subsystems is readily explainable in that the EMS system has no control or impact on this item. The "incident" is merely an event which hopefully will be detected and result in an EMS functional sequence. This same view that the EMS system is entered after the incident illness or injury was stated somewhat differently by Manegold and Silver: "When a person is confronted with an illness or injury that appears urgent to that person or his family, he enters the emergency care system." (20)

TABLE 3

INTERFACE OF FUNCTIONAL SUBSYSTEMS AS DEFINED
IN THE FRANKLIN RESEARCH
INSTITUTE STUDY

Functional Subsystems	EMS System in Operation
Entry Subsystem	a. Accident or emergency illness b. Detection c. Notification
Dispatch Subsystem	d. Dispatch
Resource Transportation Subsystem	e. Closure
Field Care Subsystem	f. Triage g. First aid h. Transport i. Stabilizing care
Facility Subsystem	j. Delivery - return ETU k. Emergency medical care l. Disposition

Table 3 outlines the interface of the five functional subsystems with Bordner's (5) view of the EMS system in operation. The five subsystems defined describe quite adequately the functional sequence. Again the subsystems exclude the actual occurrence of the accident or emergency illness for reasons previously discussed.

Summary

The EMS subsystems defined in this section have been demonstrated to be functional, in that they interface appropriately and comprehensively with the actual operating sequence of the EMS system. In addition, the subsystems are mutually exclusive, sequential, and capable of dealing with all EMS needs. Not the least important consideration is the fact that there is a relatively small number of subsystems whose boundaries are determined by an intuitively appealing separation of dissimilar activities. These attributes describe a set of subsystems appropriately structured for use in the application of MBO technique.

APPLICATION OF MANAGEMENT BY OBJECTIVES TO EMS SYSTEMS

The purpose of this report is to describe a set of ideal objectives for an emergency medical services (EMS) system from which system performance can be determined.

To achieve this purpose, it is necessary to understand the systems characteristics of EMS, as described in the previous section. Specific dimensions of the objectives statements must then be determined to ensure that performance can be meaningfully determined. Finally, a process by which the objectives are established must be developed. This process must (a) account for the particular systems characteristics of EMS, (b) yield statements of objectives which are meaningful and measureable, and (c) be useable by EMS personnel on a continuing basis. The Management by Objectives philosophy comprises the premises on which the objectives-setting process is based.

EMS Systems

EMS systems, as other systems,can be approached in terms of functions and interest groups (3). To consider the system in terms of function one must identify critical activities such as entry, resource management, resource transportation, field care, and facility care. The systems concept relates these activities on the basis of time, degree of interdependence, and importance.

Interest groups comprising the EMS system include medical societies, hospital associations, governments, the public, physicians, nurses, emergency medical technicians, and emergency facility managers. The systems concept explicitly recognizes the interdependence of these groups as well as their vested interests.

It is reasonable to study the EMS system in two-dimensional matrix form with the principal axes being functions (described by subsystems) and interest groups. This conception of the system allows the analyst to consider the interaction of functions and people, and increases the probability of complete understanding of the system.

The key characteristics of EMS systems, whether viewed functionally, by groups or in matrix form, are (a) the interdependence of several components, (b) the strong likelihood of optimization of sub-functions or groups at the expense of the total system, (c) the vested interests represented by individual functions and groups, and (d) the inherent conflict among some elements of the system--conflict which uses (wastes) valuable resources of the system for its resolution.

System Objectives

The characteristics of each EMS subsystem dictate that a set of objectives be established to which all components of the subsystem can relate. These objectives must be agreed upon by the constituents performing in the subsystem and they must be such as to allow performance measurement of the subsystem. Elements which must be included in each statement of objective (1) include: (a) the attribute considered central to the operation of the system, (b) the yardstick or unit of measure to be applied to the attribute, and (c) the goal or specific value of the unit of measure judged to be acceptable or satisfactory by the constituents.

An example objective for the resource transportation subsystem is to have average response time to emergencies over a one month period not to exceed six minutes. The attribute in this case in response time. The yardstick is an average of time units (minutes) and the goal is six. The objective with a carefully stated attribute, yardstick, and goal is clearly superior to "soft" objectives such as, "We'll do our best to get there as fast as we can," when performance measurement is desired. It should be noted that the attempt is not to maximize or optimize, but rather, to achieve a level of performance which is acceptable to all human elements of the system. The objective is not "to do our best," but to achieve an average response time of six minutes.

Management by Objectives

Management by Objectives is a philosophy which fosters the development of objectives in such a manner as to increase the likelihood that constituents of the system can agree and relate to the objectives. The key feature of MBO is agreement. This feature facilitates acceptance and commitment and it serves to reduce conflict,thus motivating people in the system to accomplish the agreed-upon objectives (10). This philosophy is used extensively in many non-health industries with dramatic results in many places. It is applicable to health care in general and to EMS systems and subsystems in particular.

One major purpose for the MBO application to EMS systems is to induce interdependent but diverse groups with strong and sometimes incompatible vested interests to be brought together to formulate acceptable subsystem objectives. The guiding principle of this application is that the subsystem objectives must be accomplished whether or not vested interests are served.

Several specific techniques are available under the rubric of MBO to establish the objectives. Only one, the Nominal Group Process (NGP), will be discussed herein since it incorporates the essential features of MBO and appears to be well suited to the key characteristics of the EMS system directly (24).

The Nominal Group Process

A nominal group requires that individuals give silent effort in a group setting. Van de Ven and Delbecq conclude that the optimal combination of group processes for a problem-solving group is: (a) the use of nominal group processes for fact finding or idea generation in the early phases of a group's work; (b) the use of structured feedback discussion in later phases; and (c) nominal group voting for final judgments in the final phase (25).

The group task with respect to the EMS system is to collectively agree on the objectives of each subsystem. Each element or component of each objective is treated singularly. To identify attributes, representatives from each significant interest group are called together and presented with the task. It is critically important that all significant groups are represented and that all representatives are treated equally. While it is true that the individuals will not perceive themselves as equals (e.g., physicians may think they are more important than EMT's), the fact remains that each person represents an element of an interdependent system. This implies that each element has veto power over the functioning of the system and therefore, each element is of equal importance in a systems context, that is, in its power to cause the system to fail.

Using NGP, individuals sit around a table in full view of each other. The meeting leader sets the stage by welcoming the people and explicitly soliciting their cooperation and commitment. He introduces the theme of the meeting which, in the present case, would be the generation of ideas about attributes of the EMS system. The leader provides the group with a statement of task, usually in the form of a question. For example, "By what criteria should the performance of an EMS entry subsystem be judged?" Without speaking, each individual records his ideas in writing. At the end of ten to twenty minutes, a structured sharing of ideas takes place. Each individual, in round-robin fashion, provides one idea from his private list which is written onto a flip-chart in full view of other members. There is still no discussion--only the recording of privately generated ideas. This round-robin listing continues until each member indicates that he has no further ideas to share. The output of this nominal process is the total set of attributes created through a structured environment. Generally, spontaneous discussion then follows for a period of time, and the discussion is followed by nominal voting. Nominal voting is a process by which the key attributes of highest priority are selected by rank ordering or rating (depending on the group's decision rule). A pooled outcome of the individual votes constitutes the group decision. The leader format designed by Van de Ven and Delbecq is attached as Appendix A (25). The first iteration of this process yields a limited set of attributes which is accepted by representatives of each significant interest group and judged to be useful in measuring the performance of a particular subsystem.

Three key decisions are made by the leader preparatory to and during the first iteration. The leader determines who should attend by identifying the critical interest groups. Secondly, the leader specifies the question to which the constituents of the group respond. The leader determines what information (concerning attributes in the present case) is needed and formulates the question to elicit this information. Finally, the leader assists the group to arrive at an appropriate number of attributes selected from the entire set of those generated by the group.

The second iteration of the process proceeds exactly as did the first, except that the task statement addresses the yardstick component of the objectives rather than the attributes. One yardstick for each attribute must be determined, and it is usually helpful to consider the attributes one at a time. The conclusion of this iteration yields a means of measuring each attribute that has been generated by the first iteration. Again, for emphasis, the representatives of the groups come to a collective judgment (consensus) about the attributes and their measurement (the yardsticks.)

The third iteration is procedurally identical to the others, the difference being in the statement of task. During this iteration attention is given to specific values judged to be acceptable. These specific values or goals become the standards of performance for the system. The concern is not for the system to maximize, minimize, or optimize; the concern is for the system to achieve its objectives, to reach the specific goals agreed upon by the constituents.

The result of these three iterations is a set of objectives which are agreed-upon, reasonable, internally consistent, and which can be used to measure the performance of the system.

The outcome of the nominal group process is a reasonable number of statements of objectives upon which constituent groups agree. Van de Ven and Delbecq argue that nominal groups generate more relevant and more creative problem statements because nominal groups (25):

a. Capitalize on tension created by the presence of others, the silence, and the evidence of activity (7).

b. Avoid evaluation or elaborating comments while problem statements are being generated, thus reducing perceived threat (19).

c. Provide each individual time to reflect (search) and force participants to record their thought (11).

d. Avoid the dominance of the group by strong personality types (18).

e. Prevent premature conclusion of the search process (19).

f. Allow all participants to share in the opportunity for influencing productive outcomes of the group (21).

g. Encourage minority opinions and ideas which probably will be voiced (17).

h. Tolerate conflicting incompatible ideas since all ideas are revealed in writing (9).

i. Alleviate "hidden agendas" or covert purposes of group members which might be incompatible with the group goal (13).

j. Induce a sense of responsibility in the members to achieve the group goal (4).

k. Impose a burden upon all participants to produce all they possibly can relevant to the group goal (2).

l. Induce a greater feeling of commitment and a greater sense of permanence by means of written records of ideas (16).

Participants in nominal groups sometimes need direction to separate personal statements of objectives from task statements. Caution must be given that personal statements are not necessarily "bad" or "good." The nominal group leader must so judge and in those cases where both types of statements are desired, the leader asks the group to think of both types. He then asks the group members what they personally should try to accomplish for themselves <u>and</u> what they think the organization should try to accomplish (8).

The careful structuring of interactions between nominal group members means that nominal groups can accomodate more people with different backgrounds than conventional groups. Nominal groups of fifteen or more are not uncommon. Large numbers in conventional groups usually result in the formation of subgroups and domination of the discussion by high-status people, thereby reducing the chances for consensus.

groups is particularly important in health care where many constituent groups of widely different status must come together to reach agreement on basic objectives and policies of health care systems. It has been shown repeatedly that heterogeneous groups in terms of background and personality produce higher quality problem solutions than homogeneous groups (5).

It should be noted that nominal groups as defined be Van de Ven and Delbecq incorporate the best features of non-interacting and interacting groups during the objective - setting process (25). Non-interaction facilitates individual search and fact-finding while interaction is necessary for synthesis, evaluation, and consensus.

One question constantly before group leaders is whether group judgments are superior to individual judgments. If group judgments are superior, then one is left with the procedure by which one group judgment is derived from several group member judgments. Mouton has shown that group judgments made after interaction are superior to judgment resulting from statistical pooling of individual judgments. This result would likely be of particular importance when the group is diverse in background-the precise circumstance encountered by those setting objectives for EMS systems (21).

The "recorded round robin" technique of securing judgments from individuals addressed three key problems unaddressed by other group consensus methods. First, this technique facilitates equal sharing of ideas on personal objective statements and organizational objective statements. Second, this technique fosters full disclosure even by those group members who otherwise would feel threatened. Third, the entire set of potential objective statements is recorded prior to discussion so that discussion can address the thinking of the entire group.

The voting procedure by rank deals specifically with the question of how group judgments are actually made. Equality of all members in the group is implied by this ranking system and this equality minimizes threat and facilitates acceptance of the final statements of objectives derived by the group.

SUMMARY

The MBO philosophy appears to be applicable to EMS systems and can be implemented through the nominal group process. Clear measurable objectives are generated to which participants agree and are commited. The use of these objectives as a link in measuring system performance is not only desirable, but required by the nature of the objectives themselves.

DERIVATION OF OBJECTIVES

This section of the report describes the process employed by project staff to derive the objectives and data to measure EMS system performance. The NGP, recommended by management consultants in the preceding section, was simulated through role-playing by various HSRC staff. A group of EMS "constituents," i.e. physicians, nurses and emergency medical technicians, was not assembled to participate in the NGP, since outside participation in the objective-setting process was specifically excluded from the project design.

Nominal Group Process Simulation

NGP was simulated for each of the five EMS subsystems developed in the first section of this report. The Entry subsystem is discussed in this section to illustrate the process.

Preparatory Functions

As a first step in NGP, the leader identified the constituents of the group. The constituents included physicians, hospital administrators, EMS system managers, hospital emergency department nurses who were involved in reception or triage activities, emergency medical technicians, and political authorities. HSRC staff personnel with EMS system knowledge were assigned one or more constituent roles to perform in the simulated NGP.

Attributes

The question posed to the various constituents was: "What should the Entry subsystem do?" Each HSRC staff member addressed the question from one constituent's point of view, and subsequently addressed the topic from another constituent's point of view, until a response was generated for each constituent of the Entry subsystem nominal group. A sample of responses to the question is presented in Table 4.

Actual nominal voting was not simulated. However, through a process of debate, nearly every objective's attribute was re-worded so as to be sufficiently general to encompass the attributes suggested by all constituents. Since general objective attributes were structured, voting was deemed unnecessary, i.e. every constituent's suggested attributes were included in the final set.

TABLE 4

A SAMPLE OF RESPONSES GENERATED THROUGH THE SIMULATED NOMINAL GROUP PROCESS

Constituent	Sample Response
Physician	"Entry should be designed in a manner that will allow my patients to get help quickly."
EMS Administrator	"Entry should teach the public-at-large when to request an ambulance and when to go directly to a hospital."
Nurse	"Entry should teach the public to use private MD's unless it is a real emergency."
EMT	"Entry should get precise information about the location, and should tell people not to leave until the ambulance gets there."
Hospital Administrator	"Entry should teach people not to call the hospital when they want an ambulance." Note: It was assumed that the hospital component of this EMS system did not control ambulance dispatching."
Political Authorities	"Entry should teach people not to call our fire department unless they live in our county."

Some of the responses elicited through NGP simulation illustrate a common problem that must be dealt with in subsequent EMS/MBO applications. Most attributes suggested by the group dealt not with what the Entry subsystem should do, but how it should be done. The suggestion of a method as an entry attribute (how an attribute is to be achieved) is appropriate if methods are to be evaluated, but not if over-all performance is to be measured. To illustrate, consider the attribute which states that "A citizen should be able to call EMS from any pay telephone, without a coin." Measurement of achievement for this attribute addresses only pay telephone access to an EMS system. The purpose of the attribute is presumably to ensure that there are no barriers to entry and that some entry mechanism is available to the general public, in public places. "Dial-tone first" pay telephones represent only one potential solution to the problem. All NGP constituents' responses that dealt with solutions as opposed to general purposes of the Entry subsystem were examined to identify the general purpose. The results of this analysis contributed significantly to the final set of generalized objectives.

Yardsticks

Yardsticks, by which achievement of an attribute is measured, can be developed by posing a second question to each nominal group. The question would be, "How do we measure this?" Rather than repeat the time-consuming NGP, however, HSRC staff collectively reviewed each attribute to determine appropriate yardsticks. The determination of realistic yardsticks that can be satisfied by collecting data that are readily available was not an issue. Hence, the derivation of "ideal" yardsticks was not difficult. For example, the attribute, "Everyone who needs to call EMS should be capable of entering the system," requires a yardstick that describes the number of entries that are attempted, and those that successfully enter the system.

Goals

The goal, when associated with a corresponding attribute and yardstick, constitutes a valid objective. In the preceding example, one goal might be 90 (per cent of all attempts should be successful). HSRC did not establish goals since the task was not relevant to the derivation of data. These goals often are referred to as performance standards; i.e., six minutes (response), one hospital (per 10,000 persons), etc. The objectives presented in this report have stated the goal quantities as an unspecified variable ("x").

Discussion of the Simulated Nominal Group Process

There are advantages and disadvantages associated with the NGP simulation. The simulation clearly approaches "conventional brainstorming," which is inferior to the nominal group. More than adequate trade-off is realized through simulated NGP, however, since the monetary and time costs associated with a true application of NGP would be prohibitive for this initial application of MBO to the EMS system.

The most significant advantage of the simulation is the relatively low cost. However, some aspects of NGP were realized. The structure imposed by NGP is believed to significantly reduce potential for errors of ommission in the analysis. All constituents were represented, conceptually, and the need to review each EMS system attribute from various viewpoints has yielded a comprehensive data list which may be used as a "straw-man" for subsequent research.

EMS SUBSYSTEMS OBJECTIVES

The simulated NGP (described in the preceding two sections) generated a total of thirty-nine objectives for the five functionally-defined EMS subsystems. Listed below are: (1) the thirty-nine objectives; (2) equations showing what specific data are required to measure each objective's goal; and (3) clarifying comments for each objective.

Entry Subsystem

1. Limit the number of non-emergency requests for medical assistance to no more than x per cent of the total requests for medical assistance.

   $$\text{Goal} \leq x\% = \frac{a}{b}$$

   Where: a = requests where medical incident did not require emergency assistance

   b = total requests for medical assistance

   Data indicate the effectiveness of all programs and other efforts to limit requests for EMS assistance to only medical emergencies.

2. Limit the number of non-emergency entries to no more than x per cent of the total entries.

   $$\text{Goal} \leq x\% = \frac{a}{b}$$

   Where: a = non-emergency entries

   b = total entries

   Data indicate the effectiveness of the Entry Subsystem's screening function -- i.e., the prevention of either non-medical or non-emergency incidents from entering the EMS system. This objective differs from Entry Objective No. 1, in that this objective intends to halt the processing of inappropriate requests at the entry function while the first Entry Objective attempts to reduce the total number of inappropriate requests for assistance.

3. Increase the number of medical emergency entries to at least x per cent of the total medical emergencies.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = medical emergency entries

b = total medical emergencies

Data measure: (1) the subsystem's medical incident detection capabilities; and (2) the effectiveness of those activities designed to encourage the public to recognize a true medical emergency and request assistance from the EMS system for all medical emergencies. In effect, the Entry Subsystem functions to screen out inappropriate entries (see Entry Objectives No. 1 and 2) and also to increase the absolute number of true medical emergency entries.

4. Cause appropriate entry-point attempts to equal at least x per cent of the total entry attempts.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = appropriate entry-point attempts

b = total entry attempts

Data indicate the effectiveness of methods employed to cause the public to enter the EMS system at an appropriate entry point. An appropriate entry point for severe emergencies might be an ambulance dispatch center. An appropriate entry point for a less severe emergency may be a facility. Attempts to enter a facility "after-hours," attempts to travel by automobile to a facility while suffering from a heart attack, or attempts to obtain an ambulance for a minor laceration might all be considered inappropriate.

5. Cause the time between perception of need for medical assistance and receipt of a request for medical assistance to be within x minutes.

$$\text{Goal} \leq x \text{ minutes} = t_2 - t_1$$

Where: t_1 = time of perception of need for medical assistance

t_2 = time of initial contact at appropriate entry point

Data indicate the accessibility of the Entry Subsystem (which, in effect, determines the accessibility of the entire EMS system) to those who need EMS assistance. The effectiveness of all subsystem activity to inform the public of the most expeditious method of entry can also be measured by the data collected for this objective.

6. Interrogate persons who report a medical emergency and transmit pertinent information to the Dispatch Subsystem in no more than x minutes.

$$\text{Goal} \leq x \text{ minutes} = t_2 - t_1$$

Where: t_1 = time of initial contact at entry point

t_2 = time of completion of information transmittal to Dispatch Subsystem

Data measure the amount of time consumed by information receipt and transmittal activities. In many EMS systems, entry-receiving personnel and dispatch personnel are one and the same. Data may be of value to systems with this personnel-sharing feature since unusual delays may be identified and, where possible, procedural changes may be instituted in an attempt to achieve the objective's goal.

7. Obtain information to accurately appraise the nature of the medical incidents for at least x per cent of the reported medical incidents.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = reports for which information is adequate to accurately determine the nature of the medical incidents

b. = total medical incident reports

Data indicate the subystem's ability to obtain accurate information relating to the nature of the medical incident (gunshot wound, burn, poisoning, heart attack, etc.).

8. Transmit to Dispatch Subsystem an accurate report of the nature each reported medical emergency for at least x per cent of the reported, apparent emergencies.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = accurate reports of the nature of the medical incident transmitted to Dispatch Subsystem

b = total reported, apparent emergencies

Data indicate the accuracy of the transmittal of the information relating to the nature of reported. apparent emergencies.

9. Obtain and transmit accurate patient-volume information for at least x per cent of the reported, apparent emergencies.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = obtained and transmitted accurate patient-volume information

b = total reported, apparent emergencies

Data indicate the accuracy of the patient-volume information (required to dispatch a sufficient, yet not excessive, quantity of EMS resources) that is obtained and transmitted.

10. Obtain and transmit accurate descriptive location information required to locate precisely the medical incident scene in at least x per cent of the reported, apparent emergencies.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = obtained and transmitted accurate location information

b = total reported, apparent emergencies

Data indicate the accuracy of the information that is obtained and transmitted pertaining to the location of the medical incident scene.

11. Obtain and transmit accurate environmental control information in at least x per cent of the reported, apparent emergencies.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = obtained and transmitted accurate environmental control information

b = total reported, apparent emergencies

Data indicate the accuracy of the environmental control information that is obtained and transmitted. Environmental control information consists of information that describes unusual environmental conditions at the scene of a medical emergency. Fire, explosive material, gun-battles, and similar situations would require environmental control.

Dispatch Subsystem

1. Analyze emergency assistance request information from the Entry Subsystem and notify the Resource Transportation Subsystem within x minutes.

   Goal $\leq$ x minutes $= t_2 - t_1$

   Where: t_1 = time of receipt of all medical incident information

   t_2 = time of completion of dispatch command

   Data will indicate the time consumed by the analysis of medical request information (nature of medical incident, patient volume, and location) and the time required to transmit (dispatch command) appropriate information to Resource Transportation. "Analysis" of information may include a determination of the of the type of EMS resource that may be required and the closest available resource (for the most rapid response).

2. Dispatch an appropriate quantity and mix of EMS resource-units for at least x per cent of the requests for emergency assistance.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = medical incidents with an appropriate quantity and mix of EMS resource-units dispatched

   b = total requests from the Entry Subsystem for emergency medical assistance

   Data will indicate the appropriateness of the quantity and mix of EMS resource-units dispatched. "Appropriateness" of dispatch command is based upon the information received from the Entry Subsystem. The Dispatch Subsystem is not responsible for the accuracy of entry information.

3. Receive at least x per cent of the required status information reports from the Resource Transportation and Field Care Subsystems.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = required status information reports received

   b = total required status information reports

Data will indicate the relative number of the required status information reports that are received from Resource Transportation and Field Care. Although these status information reports are normally initiated by the personnel associated with the Resource Transportation and Field Care Subsystems (drivers, EMT's, etc.), these same personnel are performing a Dispatch Subsystem function when reporting status information. In addition, it is the responsibility of the dispatch function to monitor these reports and to request status reports if field resources fail to report as expected.

Resource Transportation Subsystem

1. Transport dispatched EMS resource-unit to medical incident scene within x minutes after receipt of command.

$$\text{Goal} \leq x \text{ minutes} = t_2 - t_1$$

Where: t_1 = time of completion of dispatch command

t_2 = time of arrival at medical incident scene

Data will indicate the amount of time that Resource Transportation consumes between dispatch command and the arrival of resources at the medical incident scene.

2. Transport dispatched EMS resource-unit to medical incident scene at an average speed not to exceed x miles per hour.

$$\text{Goal} \leq x \text{ miles per hour} = \frac{d_2 - d_1}{t_2 - t_1} \times \frac{60 \text{ minutes}}{1 \text{ hour}}$$

Where: d_1 = odometer reading at initiation of vehicle response

d_2 = odometer reading at completion of vehicle response

t_1 = time of initiation of vehicle response

t_2 = time of completion of vehicle response

Data will measure the number of incidents that the EMS resource-units travel to the medical incident scenes at a safe velocity. Goals would vary depending upon resource-unit speed capabilities (e.g., ambulance vs helicopter) and travel conditions (e.g., downtown traffic vs open highway).

3. Limit applicable responses without the use of warning devices to no more than x per cent of total responses.

$$\text{Goal} \leq x\% = \frac{a}{b}$$

Where: a = applicable responses without warning devices

b = total applicable responses

All Resource Transportation responses are predicated upon the assumption that a true medical emergency exists; therefore, warning devices (siren and/or flashing lights) should be utilized for every applicable response (helicopter responses are not applicable). Data will indicate to what degree the warning devices are being utilized.

4. Limit the number of incidents where an item of the resource-unit's standard equipment is either not transported or inoperable to no more than x per cent of the incidents where such an item is required for patient care.

$$\text{Goal} \leq x\% = \frac{a + b}{c}$$

Where: a = standard equipment item not transported

b = standard equipment item not operable

c = standard equipment item required

Data will indicate the effectiveness of care (inspections, maintenance, etc.) taken to assure that all standard resource-unit equipment is available and in good working order when necessary.

5. Limit unnecessary transportation of each item of the resource-unit's standard equipment to no more than x per cent of the total completed responses.

$$\text{Goal} \leq x\% = \frac{a}{b}$$

Where: a = standard equipment item not required

b = total completed responses

These data, in conjunction with data obtained for Resource Transportation Objective No. 6, will provide information to evaluate the quantity and mix of the standard equipment transported to each medical incident scene. The utilization of each item of standard equipment is determined.

6. Limit the number of incidents where a resource-unit's standard equipment proves to be inadequate for patient care to no more than x per cent of the total completed responses.

$$\text{Goal} \leq x\% = \frac{a}{b}$$

Where: a = standard equipment proves inadequate

b = total completed responses

Data from this objective describe the relative frequency with which items of resource-unit's non-standard equipment (not routinely provided at the scene) could have proven to be of value to the patient. Periodic review of these utilization data and data from the previous Resource Transportation objective will provide information necessary to maintain an appropriate mix of standard equipment.

7. Return to "available" status in no more than x minutes after medical responsiblity has been relieved at the medical incident scene or emergency facility.

$$\text{Goal} \leq x \text{ minutes} = t_2 - t_1$$

Where: t_1 = time of completion of medical responsiblity

t_2 = time of completion of "available" status report

Data will indicate the delay incurred between the completion of one response and the return to an "available" status for the next response.

Field Care Subsystem

1. Cause appropriate field care to begin prior to the arrival of EMS resources in at least x% of the total reported, apparent emergencies.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = reported, apparent emergencies where appropriate field care is initiated before the arrival of EMS field care resources

b = total reported, apparent emergencies

Data will indicate the effectiveness of efforts to encourage the public to apply emergency first aid techniques. These data may evaluate training of non-EMS personnel and also the medical self-help instructions provided by Entry personnel at the time that a request for emergency medical assistance is received.

2. Perform triage without error for at least x per cent of applicable medical incidents.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = incidents where triage is performed without error

   b = total medical incidents where triage is applicable

   Data will indicate the accuracy of the triage function performed at the medical incident scene. Incidents with only one patient require no triage and should not be included in the data.

3. Complete triage function within x minutes after arrival at medical incident scene.

   Goal $\leq$ x minutes $= t_2 - t_1$

   Where: t_1 = time of arrival at medical incident scene

   t_2 = time of initiation of diagnostic function

   Data measure the time required for triage to be initiated and completed at the medical incident scene.

4. Accurately diagnose at least x per cent of the patient's total significant ailments.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = significant ailments diagnosed

   b = total significant ailments

   Data indicate the accuracy of the diagnosis of the patient's significant ailments at the scene.

5. Appropriately treat at least x per cent of the patient's diagnosed, significant ailments.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = appropriately treated significant ailments

   b = total diagnosed, significant ailments

   Data indicate the quality (appropriateness) and/or completeness of treatment given to the patient's diagnosed, significant ailments at the medical incident scene.

6. Complete diagnosis and treatment functions at the medidcal incident scene within x minutes.

   Goal $\leq$ x minutes $= t_2 - t_1$

   Where: t_1 = time of initiation of diagnostic function

   t_2 = time of completion of treatment function at the medical incident scene

   Data indicate the time in which the diagnosis and treatment functions are completed at the medical incident scene. These two functions have been combined into one time measurement since they inherently often occur simultaneously.

7. Correctly refer patients in at least x per cent of the total patient referrals.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = correct patient referrals

   b = total patient referrals

   Data indicate the accuracy of the patient referral decisions (to emergency facility, private physician, etc.) made at the medical incident scene. Evaluation of a referral to a emergency facility would take into consideration the selection of a facility with appropriate capabilities.

8. Transport patients needing emergency facility care from the medical incident scene to the appropriate emergency facility within x minutes.

   Goal $\leq$ x minutes $= t_2 - t_1$

   Where: t_1 = time of initiation of patient transport to emergency facility

   t_2 = time of arrival at appropriate emergency facility

   Data indicate the time consumed while transporting a patient from the medical incident scene to an appropriate emergency facility. These data can be utilized to evaluate the speed of the transport function and also the geographical placement and quantity of facilities.

9. Transport patients needing emergency facility care from the medical incident scene to the emergency facility at an average speed not to exceed x miles per hour.

$$\text{Goal} \leq x \text{ miles per hour} = \frac{d_2 - d_1}{t_2 - t_1} \times \frac{60 \text{ minutes}}{1 \text{ hour}}$$

Where: d_1 = odometer reading at initiation of patient transport by vehicle

d_2 = odometer reading at completion of patient transport by vehicle

t_1 = time of initiation of transport by vehicle

t_2 = time of completion of transport by vehicle

Data indicate the incidents that the vehicular transport of the patient was performed at a safe velocity. Specific velocity goals will vary depending upon the vehicle and the conditions (see Resource Transportation Objective No. 2).

10. Limit inappropriate use of warning devices during patient transportation to no more than x per cent of total patient transports.

$$\text{Goal} \leq x\% = \frac{a}{b}$$

Where: a = incidents of inappropriate use of warning devices

b = total patient transports

Data indicate the frequency of the inappropriate use of warning devices during patient transportation from the medical incident scene to an emergency facility. Inappropriate use of warning devices would include failure to use warning devices when necessary and also use of warning devices when they should not be used.

Facility Subsystem

1. Accurately triage at least x per cent of the total patients entering the facility.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = patients triaged accurately

b = total patients entering the facility

Data will indicate the accuracy of the triage function performed at the facility. Failure to triage a patient will be considered an inaccurate triage.

2. Complete triage function within x minutes after the patient enters the facility.

   Goal $\leq$ x minutes $= t_2 - t_1$

   Where: t_1 = time of entry into facility

   t_2 = time of completion of triage function

   Data indicate the time consumed by the facility triage function.

3. Begin diagnosis within x minutes after the completion of the triage function.

   Goal $\leq$ x minutes $= t_2 - t_1$

   Where: t_1 = time of completion of triage function

   t_2 = time of initiation of diagnostic function

   Data will identify and measure delays between completion of triage and the initiation of diagnostic activity.

4. Accurately diagnose at least x per cent of significant patient ailments.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = accurately diagnosed significant ailments

   b = total significant ailments

   Data will indicate the accuracy of the diagnosis of each significant ailment.

5. Appropriately treat at least x per cent of diagnosed, significant ailments.

   Goal $\geq$ x% $= \frac{a}{b}$

   Where: a = appropriately treated diagnosed, significant ailments

   b = total diagnosed, significant ailments

   Data will indicate the quality (appropriateness) and completeness of treatment for each patient's diagnosed, significant ailments.

6. Complete diagnostic and treatment functions within x minutes.

$$\text{Goal} \leq x \text{ minutes} = t_2 - t_1$$

Where: t_1 = time of initiation of diagnostic function

t_2 = time of completion of treatment function

Data measure the time required to perform diagnostic and treatment functions.

7. Accurately refer the patient in at least x per cent of total patient referrals.

$$\text{Goal} \geq x\% = \frac{a}{b}$$

Where: a = accurate patient referrals

b = total patient referrals

Data will indicate the accuracy of the patient referrals to private physicians, inpatient services and other acute care departments.

8. Refer patients within x minutes after the completion of the treatment function.

$$\text{Goal} \leq x \text{ minutes} = t_2 - t_1$$

Where: t_1 = time of completion of treatment function

t_2 = time of completion of referral function

Data measure the delay between treatment and referral of patients to medical services outside of the emergency department.

SUMMARY OF SURVEY RESPONSES

In an attempt to gather comments from EMS system authorities concerning the perceived utility of data derived through MBO, and to solicit comments relevant to potential data collection problems, HSRC designed and administered a survey to twenty EMS system sites in the United States. This section of the report presents a summary of comments received in response to the EMS System Objectives and Data Assessment Survey.

The survey, illustrated in Appendix C, solicits four sets of comments from the EMS system authorities who participated in the analysis. These four sets of comments include comments which are relative to data collection and data utility, miscellaneous comments for each objective and corresponding data, and general comments relevant to an analysis of all data viewed collectively. Each set of significant survey responses is discussed separately, and where appropriate the comments are summarized in tabular form.

Twenty survey forms were mailed to the persons identified in Appendix D. Only thirteen complete or partially completed survey forms were returned. Follow-up activity was conducted to determine the reasons for failure to complete the survey as agreed, but of the seven sites that did not perform, only two could be contacted. One EMS authority stated that he did not have time. The other EMS authority did not understand the task and replied too late to allow for subsequent processing of the survey.

Tabulated Summaries

Specific responses to the EMS System Objectives and Data Assessment Survey questions relating to data collection and data utility are summarized in Tables 5 through 8 in this section of the report. Discussion of the comments is presented immediately following each set of tabulated summaries.

Data Collection Comments

Table 5 summarizes comments regarding potential data collection problems associated with the data presented in the EMS System Objectives and Data Assessment Survey. Each response to the survey questions "Do you perceive any problems (cost, feasibility, etc.) in the collection of these data? If so, what are they?" is classified into one or more of five categories: No Major Problems, Unreliabile, Uneconomical, No Comment, and Other.

The consulting EMS authorities often cited more than one problem. Therefore, each response may be classified into more than one category. Only the "No Major Problem " and "No Comment" categories correspond on a one-to-one basis to the comments received and categorized. Thus, for Entry objective number one (1), as shown in Table 5, it is safe to assume that six "No Major Problem " responses were received, and also that six of the thirteen EMS sites provided only this response to the first survey question.

The data presented in Table 5 allow the reader to determine information relative to each objective presented in the preceding section entitled EMS Subsystem Objectives. For the purposes of this discussion only the "No Comment" column of Table 5 is addressed. The number of responses categorized as "No Comment" varies considerably among subsystems, from two (2) to nineteen (19) responses. The combined total of "No Comment" responses for the Entry, Dispatch, Resource Transportation and Field Care subsystem (which constitute a typical ambulance service) equals sixteen (16). The ratio of these responses to the number of objectives multiplied by the number of respondents (maximum possible responses) equals 0.0397. These same calculations applied to the Facility subsystem yield a ratio of 0.1827, which is approximately 4.6 times greater than the ratio for all other subsystems. This may indicate a significant difference in the comprehension of facility and ambulance service performance measures among EMS system authorities.

Table 6 presents data which illustrate (as percentages) the relative number of survey responses recorded in each category for each subsystem and the total EMS System.

TABLE 5

CATEGORIZED SURVEY RESPONSES RELATED TO DATA COLLECTION PROBLEMS

Subsystem	Objective Number	Number of Survey Responses Categorized as:				
		No Major Problem	Unreliable	Uneconomical	No Comment	Other
Entry	1	6	2	2	0	5
	2	6	0	2	0	6
	3	1	3	4	0	9
	4	3	3	5	1	4
	5	3	6	1	0	4
	6	7	3	1	1	1
	7	3	4	2	1	4
	8	6	1	1	2	3
	9	8	1	1	1	2
	10	9	1	0	0	3
	11	8	3	0	0	2
	Total	60	27	19	6	43
Dispatch	1	9	1	1	0	2
	2	8	3	0	0	2
	3	6	0	0	2	5
	Total	23	4	1	2	9
Resource Trans-portation	1	9	2	0	0	2
	2	6	3	1	0	5
	3	7	1	1	1	3
	4	5	4	3	0	3
	5	4	2	2	2	5
	6	5	3	2	0	4
	7	9	1	0	1	2
	Total	45	16	9	4	24

(Table 5 continued on next page)

TABLE 5

CATEGORIZED SURVEY RESPONSES RELATED TO DATA COLLECTION PROBLEMS (Continuation)

Subsystem	Objective Number	Number of Survey Responses Categorized as:				
		No Major Problem	Unreliable	Uneconomical	No Comment	Other
Field Care	1	6	5	1	0	1
	2	2	4	2	1	4
	3	2	5	1	1	4
	4	6	2	3	0	2
	5	4	4	2	0	3
	6	2	2	0	0	9
	7	7	2	2	0	3
	8	6	0	1	1	5
	9	5	1	1	0	6
	10	5	3	2	1	2
	Total	45	28	15	4	39
Facility Care	1	5	2	3	1	4
	2	3	3	3	2	4
	3	1	1	4	3	7
	4	4	2	1	1	6
	5	3	2	4	2	4
	6	2	0	1	5	5
	7	3	3	1	2	5
	8	3	1	2	3	4
	Total	24	14	19	19	34
ALL SUBSYSTEMS	Total	197	89	63	35	149

TABLE 6

RELATIVE NUMBER OF DATA COLLECTION
RESPONSES BY CATEGORY

Subsystem	Total Responses	Per Cent of Responses Categorized as:				
		No Major Problem	Unreliable	Uneconomical	No Comment	Other
Entry	155	39	17	12	4	28
Dispatch	39	59	10	3	5	23
Resource Transport.	98	47	16	9	4	25
Field Care	131	34	21	12	3	30
Facility	110	22	13	17	17	31
Total (All Sub-Systems)	533	37	17	12	6	28

The data presented in Table 6 are more easily analysed. The survey responses indicate that 37% of the MBO-derived data are collectable with "No Major Problem." Data collection for Facility subsystem data received the lowest number of responses and Dispatch subsystem received the highest number of responses in this "No Major Problem" category. The Facility subsystem received the greatest number of responses in the "uneconomical" category, and the Field Care subsystem, where EMT's record data to evaluate their own performance, received the highest number of responses in the "Unreliable" category.

A review of the comments, which are available verbatim to the Bureau of Health Services Research, shows that responses in the "Other" category are usually consistent with responses in the remaining categories. Comments such as "You'll never get physicians to record this data" are found on questionnaires that describe data collection as being uneconomical. Similarly, many consultants stated that their EMS system already collected data which they described as being collectable with no major problem. The wide range of comments in the "Other" category precluded summarization in this document.

Data Utility Comments

Tables 7 and 8 present a summary of comments relevant to the utility of the data which were derived through an application of MBO to the EMS system. The comments were received in response to the EMS System Objectives and Data Assessment Survey. Question: "What is your perception of the data's utility for the evaluation of an EMS system" The summary was designed after a review of the completed survey form d ummarizes the opinion of all survey respondents.

Some respondents described the utility f the data as a function of of an assumed cost for data collection, i.e., comments indicate the reviewer's impression that data would not be useful due to the high cost of data collection. The frequency of this type of response to the survey is not believed to be significant.

Occasionally a reviewer would present an opinion that the data would (or would not) be useful unless certain peripheral and qualifying conditions were also applicable to the EMS system. The frequency of these comments is indicated in the "Qualified" column of Table 7 and Table 8.

With the exception of the "Qualified" column, the comments from each survey are not described in more then one column of the tables. Thus, for each objective the total number of comments recorded and categorized equals thirteen (excluding responses in the "Qualified" column),which corresponds to the number of completed survey forms returned to HSRC.

TABLE 7

SUMMARY OF COMMENTS CONCERNING DATA UTILITY

Subsystem	Objective Number	Utility Recorded as:			
		High	Low	No Comment	Qualified
Entry	1	11	2	0	2
	2	11	2	0	1
	3	9	4	0	2
	4	8	5	0	2
	5	8	5	0	2
	6	11	2	0	2
	7	11	1	1	2
	8	11	2	0	1
	9	8	4	1	2
	10	9	4	0	1
	11	8	5	0	2
	Total	105	36	2	19
Dispatch	1	12	1	0	0
	2	9	2	2	1
	3	11	1	1	0
	Total	32	4	3	1
Resource Transport.	1	13	0	0	2
	2	5	8	0	2
	3	7	6	0	1
	4	11	2	0	1
	5	5	6	2	1
	6	9	4	0	1
	7	10	3	0	1
	Total	60	29	2	9

(Table 7 continued on next page)

TABLE 7

SUMMARY OF COMMENTS CONCERNING DATA UTILITY
(Continuation)

Subsystem	Objective Number	Utility Recorded as:			
		High	Low	No Comment	Qualified
Field Care	1	12	1	0	2
	2	8	4	1	3
	3	3	9	1	0
	4	10	2	1	2
	5	10	2	1	1
	6	7	5	1	0
	7	10	3	0	3
	8	9	4	0	2
	9	6	6	1	1
	10	6	6	1	0
	Total	81	42	7	14
Facility	1	12	1	0	1
	2	7	4	2	4
	3	7	4	2	2
	4	8	3	2	4
	5	8	3	2	3
	6	6	5	2	3
	7	9	2	2	3
	8	7	3	3	4
	Total	64	25	15	24
All Sub-Systems	Total	342	136	29	67
	%	67.5	26.8	5.7	N.A.

Table 8 presents data which describe, as percentages, the relative number of survey responses recorded in each category for each subsystem and the total EMS system. The "qualified" column is not included.

TABLE 8

RELATIVE NUMBER OF DATA UTILITY RESPONSES BY CATEGORY

Subsystem	Percent of Responses Categorized as:		
	High Utility	Low Utility	No Comment
Entry	73.4	25.2	1.4
Dispatch	82.0	10.3	7.7
Resource Transport.	65.9	31.9	2.2
Field Care	62.3	32.3	5.4
Facility	61.5	24.0	14.5
All Sub-systems	67.5	26.8	5.7

Table 7 is presented to provide the reader with a summary of comments which pertain to each objective and corresponding data. With the exception of the "No Comment" information presented in Table 7, the discussion of comments relevant to data utility is based upon the information provided in Table 8.

The frequency of the "No Comment" response is greatest in the Facility subsystem portion of the HSRC survey. Over 14% of the comments categorized for this subsystem were designated "No Comment." Nearly eight per cent of the potential Dispatch subsystem comments were categorized in this category, although the absolute number of "No Comment" responses for this subsystem (three) was only one larger than the minimum for any subsystem (two "No Comment" responses).

There were seven "No Comment" responses associated with Field Care data, which accounts for over five per cent of all comments received for this subsystem. It is presumed that a "No Comment" response is indicative of less than thorough knowledge on the part of the EMS authority respecting the objective and data in question.

The information presented in Table 8 indicates that most of the data proposed through the MBO process application (67.5%) were perceived as being useful. The lowest "High" utility score was recorded for the Facility subsystem and the next lowest score was recorded for Field Care data. Most of the data proposed for these subsystems deal indirectly with medical aspects of the EMS system.

Entry and Dispatch subsystem data received the highest percentage of "High" utility responses. Resource Transportation received a relatively low score, 65.9 per cent. Data for two objectives of this subsystem, numbers 2 and 5 received a lower rating than anticipated. Data for objective number 2 dealt with the speed of vehicle travel. Data for objective number 5 related to the number of times standard (routinely-stocked) equipment is carried to a victim. HSRC staff is of the opinion that most consulting EMS authorities misunderstood this objective. Several comments such as "we need to carry this equipment regardless of how often it is used" were received. Apparently, reviewers failed to consider that the utilization related goal for this objective could be established as a very small number. Indeed, if a piece of essential equipment is never used, some consideration should be given to its removal from the transport unit. If categorized responses for these two Resource Transportation Objectives are deleted from the calculations the score of "High" utility responses for this subsystem would increase to 76.9 per cent.

Miscellaneous Comments

The range of miscellaneous comments received on the survey form is too great to permit an all inclusive summary in this narrative. However, all comments are presented verbatim under a separate cover.

The miscellaneous comments received on the survey form included several statements of general interest that related to the objectives rather than to data. Many respondents used this space on the survey form to criticize or praise the objective, often by describing some historical experience to illustrate their point. Some persons expressed opinions regarding what the goal for some objectives should be. Occasionally, opinions regarding the data, suggestions for data collection techniques (none of which were innovative), or warnings regarding possible data collection problems in special situations were presented. It is worthwhile to note that the miscellaneous comments deal primarily with solutions to problems, or methods for achieving objectives. It is not proper to consider measurement of techniques for achieving goals until the level of achievement is known. To illustrate, consider Entry Subsystem objectives. This set of objectives presents a set of attributes that deal with "appropriateness," but do not specify any method for achieving "appropriateness." Public education programs, a method for achieving an objective, are often cited in comments made by consulting EMS authorities in the Entry portion of the survey. Comments of this type indicate that EMS system authorities are often methods-oriented.

This (common) thought orientation presents a problem to MBO applications, because data collected to measure the performance of a method for achieving an objective does not necessarily reflect achievement of an objective. The data presented in the HSRC survey were probably evaluated with respect to existing methods, rather than as tools to measure the achievement of generalized goals.

General Comments

The general comments received from the consulting EMS authorities to describe their impressions of the entire set of objectives and data are presented verbatim in a separate document, submitted to the Bureau of Health Services Research. Of the thirteen sets of comments, five were evaluated as favorable (expressing a positive attitude towards MBO-derived data), five were judged to be unfavorable, and three included comments that can be best described as "middle of the road." The comments varied from "Not at all useful" and "ridiculous" to "very good" and "extremely useful."

One respondent felt that the proposed data set was not adequate, because outcomes were not addressed. Several persons had expressed concern over data collection problems. One respondant demonstrated particulary good insight by stating that judgment should be withheld until goals are established.

With perhaps two exceptions, most comments seemed to indicate that the respondents did not fully understand the questionnaire's objective and goal related approach.

FOLLOW-UP SITE VISITS

Two EMS system sites, Dallas, Texas and Dade County, Florida, were visited after responses to the HSRC EMS System Objectives and Data Assessment Survey were received and reviewed. The purpose of these visits was to obtain additional information from the sites relevant to potential real-life applications of the Management by Objectives technique.

Site selection for visits was based upon two factors: (1) the existence of data collection systems or plans for data collection systems, and (2) an indication, on the HSRC survey, that the respondent was knowledgeable of data use respecting goal or objective related management. Significant notes, impressions and materials obtained at these sites are discussed below.

Dade County, Florida

The Dade County, Florida EMS system is not fully operational, but several aspects of the system have been planned. Within the county there are twenty-seven municipalities, ten of which provide some type of emergency medical service. Field care and resource transportation responsibilities are shared among numerous ambulance companies and some fire department "rescue" services.

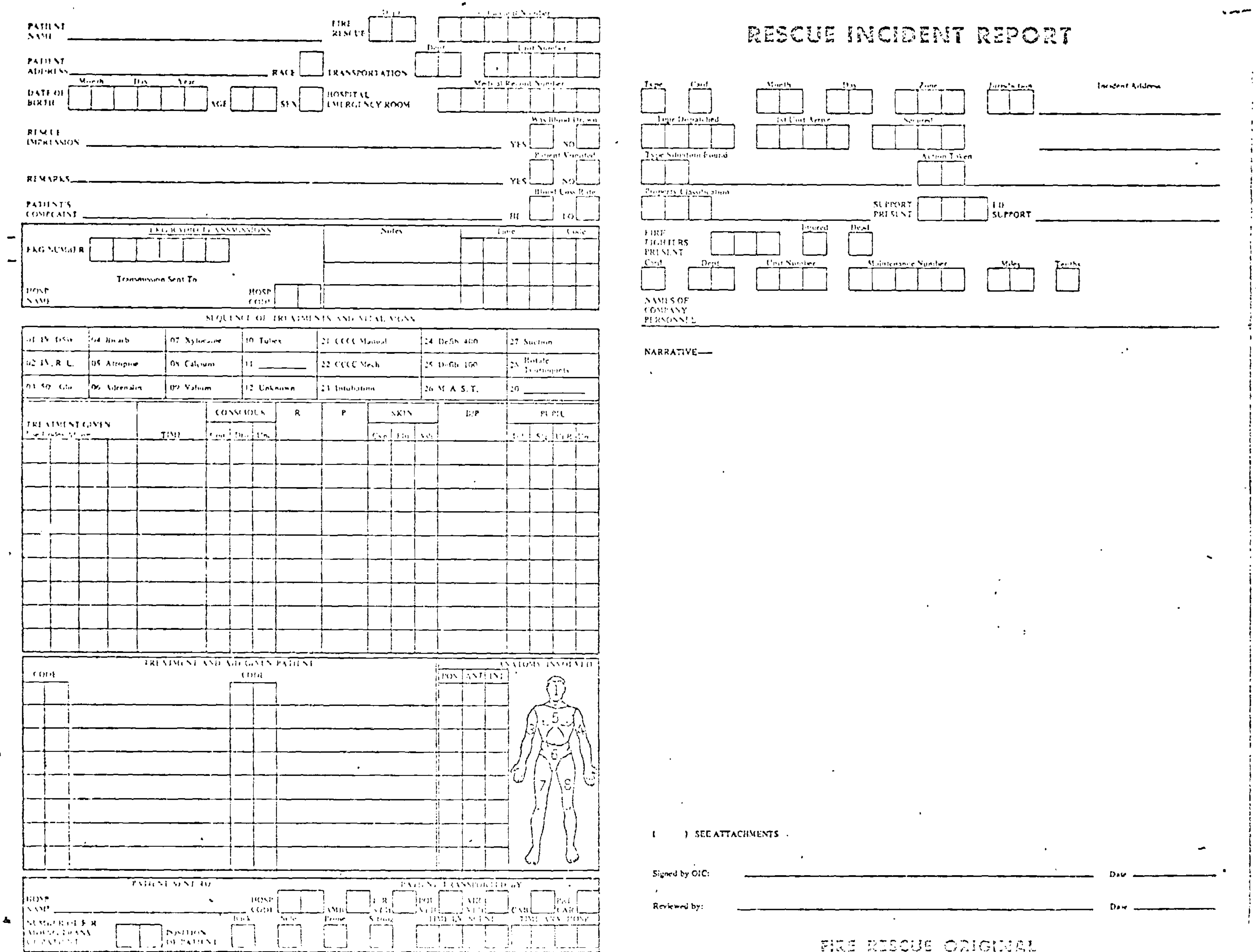
Existing Data and Data Collection

Recently, use of the data collection form illustrated in Figure 2 was implemented in Dade County. The form is completed by Fire Rescue, ambulance, and by hospital personnel. Entry, Dispatch, and Facility subsystem data are not included, although hospital medical record numbers are entered onto the form to facilitate collation of data between the Facility subsystem and other EMS system components.

Although it is not fair to assume that the data needs of this form were derived with no regard to system management needs, it is generally agreed that the various types of data were not derived specifically for this purpose. Much of the data may prove to be valuable, but there are no advance plans for utilization of any of these data in any particular manner. The introduction to this new data gathering instrument, presented in Appendix F, states: "Hopefully this will aid in budgeting and stocking many items now required to provide Emergency Medical Rescue Service."

Management Techniques

An illustration of this system's objectives is presented in Appendix G. Under the definitions imposed by MBO the appended document, entitled



PATIENT NAME — FIRE RESCUE — Incident Number

PATIENT ADDRESS — RACE — TRANSPORTATION — Unit Number

DATE OF BIRTH (Month, Day, Year) — AGE — SEX — HOSPITAL EMERGENCY ROOM — Medical Record Number

RESCUE IMPRESSION — YES — NO

REMARKS — YES — NO

PATIENT'S COMPLAINT — HI — LO

EKG NUMBER — Notes — Time — Code

Transmission Sent To

HOSP NAME — HOSP CODE

SEQUENCE OF TREATMENTS AND VITAL SIGNS

01 IV D5W	04 Bicarb	07 Xylocaine	10 Tubex	21 CCCC Manual	24 DeSib 400	27 Suction
02 IV R.L.	05 Atropine	08 Calcium	11 ______	22 CCCC Mech	25 D-Fib 160	28 Rotate Tourniquets
03 50 Glu	06 Adrenalin	09 Valium	12 Unknown	23 Intubation	26 M.A.S.T.	29 ______

TREATMENT GIVEN — TIME — CONSCIOUS — R — P — SKIN — B/P — PUPIL

TREATMENT AND ADVICE GIVEN PATIENT — CODE — CODE — ANATOMY INVOLVED

PATIENT SENT TO — PATIENT TRANSPORTED BY

HOSP NAME — HOSP CODE — AMB — F.R. VEH — POL VEH — AIR VEH — CAB — PVT CAR

NUMBER OF PERSONS — POSITION OF PATIENT — Back — Side — Prone — Sitting — TIME ON SCENE — TIME AVAILABLE

RESCUE INCIDENT REPORT

Type — Card — Month — Day — Zone — Jurisdiction — Incident Address

Time Dispatched — 1st Unit Arrive — Secured

Type Situation Found — Action Taken

Property Classification — SUPPORT PRESENT — FD SUPPORT

FIRE FIGHTERS PRESENT — Injured — Dead

Card — Dept — Unit Number — Maintenance Number — Miles — Tenths

NAMES OF COMPANY PERSONNEL

NARRATIVE—

( ) SEE ATTACHMENTS

Signed by OIC: ______ Date ______

Reviewed by: ______ Date ______

FIRE RESCUE ORIGINAL

Figure 2. Dade County "RESCUE INCIDENT REPORT"

"The Objectives of EMS Communications System," would more appropriately be titled "The Attributes of EMS Communications System." Yardsticks and measurable goals are not specified. At the present time the management techniques employed at the site are not relevant to performance data, and are characterized by the consultant as "Cooperation by Non-Interference."

Dallas, Texas

The EMS system in Dallas is typical of many and consists of an ambulance system and hospitals. Entry subsystem activity is performed by the Fire Department (ambulance system) and presumably by the individual hospitals. The Facility subsystem is separate from the Fire Department.

Existing Data and Data Collection

The "Patient Form" presented in Figure 3 is used by the Fire Department to record data for Resource Transportation and Field Care Management. These data are used by the Fire Department to manage the system resources by periodically reviewing ambulance placement strategies and staffing/unit availability patterns. In addition, using Management by Exception principles, the data are used to identify performance that deviates noticeably from the "norm." Computerized summaries are available.

As in the Dade County system, and many other systems (based upon HSRC experiences), these data are collected in the hope that they will be useful. This is not to imply that the data were derived in anything less than a conscientious manner. However, meaningful relationships between the data set and established, documented goals are absent. Comparisions among various measurements made in the Dallas system <u>do</u> provide excellent indicators for management according to "exception" principles.

Dispatch and some Entry subsystem data in the Dallas system are gathered using the form shown in Figure 4. These data do not relate to dispatch performance as described in the Dispatch subsystem objectives of this report, although some data, such as "Hospital Notified", may be useful to this subsystem. The "Source of Alarm" data on the form describe public behavior relevant to Entry subsystem activity, but apparently are not related to any specific goal in the EMS system.

Management Techniques

Although the objectives (as defined in MBO applications) are not specified in the Dallas system, some indirect relationship among data and desired performance goals exist. As stated previously, Management by Exception techniques are used. The goals for this system may be present as the unstated "norms" referred to in the preceding section. Of interest to the data collection efforts in this and other systems is the site consultant's observation that requests for data are more prevalant from outside sources, e.g., government, news media, "people from Georgia Tech," etc., than from within the system!

Figure 3. Dallas, Texas "PATIENT FORM"

DALLAS FIRE DEPARTMENT
EMERGENCY MEDICAL SERVICES

PATIENT FORM

False or No Transport 1 2 3 4 5 6

Incident Number ______ ______ of ______ Patients

Police ☐ On Scene ☐ Requested   Date ______ Time ______ AM PM   Charge ______

Envelope Issued ☐

Location ______ Hospital ______

Patient Name ______ Birthdate ______ M ___ F ___ Race ______

Street ______ City & State ______ Zip ______

Responsible Adult ______ Phone ______

Medicare # ______ Medicaid # ______

Employer ______

Paramedic/EMT ______ No. ______ Ambulance ______

Paramedic/EMT Dr. ______ No. ______ Shift ______

Vital Signs: B P ______ Pulse ______ Resp. ______ Allergies ______

Severity	Type of Injury or Illness		Drugs	Aid Provided By Paramedic/EMT
Consciousness: Con Semi Unc	☐ Agg. Assault	☐ Gunshot	☐ Sodium Bicarb	☐ EKG
Bleeding: Non Min Mod Sev	☐ Alcohol	☐ Heart	☐ Lidocaine 1%	☐ Telemetry
Pain: Non Min Mod Sev	☐ Asthma	☐ Hypervent.	☐ Lidocaine 4%	☐ IV
Location of Injury-Illness	☐ Auto Accident	☐ Hypoglycemia	☐ Atropine	☐ Drugs
☐ Head	☐ Bite/Sting	☐ Maternity	☐ Isuprel	☐ Defib-Suc.
☐ Face	☐ Burn	☐ Medical Emer.	☐ Levophed	☐ Defib-Unsuc.
☐ Eye	☐ Convulsions	☐ Muscle/Skelat	☐ Epinephrine	☐ Esoph-Airway
☐ Neck	☐ Cuts/Bruises	☐ Overdose	☐ Calcium Chl.	☐ Intubated
☐ Back	☐ Diabetic	☐ Poisoning	☐ Benadryl	☐ Oxygen
☐ Chest	☐ Drowning	☐ Psychiatric	☐ Valium	☐ CPR-Suc.
☐ Abdomen	☐ Drug Reaction	☐ Shock	☐ Dextrose 50%	☐ CPR-Unsuc.
☐ Pelvic Region	☐ Dyspnea	☐ Sickle Cell	☐ ______	☐ Cont. Bleed
☐ Upper Extremity	☐ Electrocution	☐ Stabbing	☐ ______	☐ Bandaging
☐ Lower Extremity	☐ Emer. Trans.	☐ Stroke	**IV**	☐ Splinting
☐ Respiratory	☐ Emphysema	☐ Suffocation	☐ Ringers Lac.	☐ Spine Board
☐ Cardiovascular	☐ Fainted	☐ Suicide	☐ D5W	☐ Anti-Shock
☐ Other	☐ Female Comp.	☐ T.B.	**Response Code to Hospital**	☐ OB-Live Br.
	☐ Flu	☐ VD	☐ 1	☐ OB-Still Br.
	☐ Fracture	☐ None	☐ 3	☐ Rotating TK
	☐ GI Complaint	☐ Other (Specify) ______		☐ Trans. Only
				☐ None
				☐ Other

Remarks ______

Aid Provided By
Fire Co. # ______
Police # ______
Doctor's Name ______

Preliminary Admitting Diagnosis by Hospital ______

Doctor or R.N. signature below does not approve or disapprove above information

DFD Form 200 Revised Aug. 74

Dr. or R.N. ______
Signature Accepting Patient

AMBULANCE DIVISION ALARM REPORT

D.F.D FORM 136
REV. AUG. 12, 1973

INCIDENT NO:		UNIT DISPATCHED:				DATE:
SOURCE OF ALARM	TEL:	POL:	RADIO:	STILL:	COMP:	DISPATCH TIME:

TYPE CALL: S/C H/A O/D O/B 7/X I/P U/P GSW STAB

OTHER:

ARRIVED ON LOCATION:

LOCATION:

RESPONSE TIME:

APT.

LEFT LOCATION:

X—STREET:

TRANSPORTED TO: 1 2 3 4 5

ARRIVED HOSPITAL:

PICK UP MADE: | NOT MADE: | OTHER:

PATIENT INFO	NUMBER PATIENTS	SEX	AGE	COND.	B/P	PULSE	RESP.	E.T.A.
	1 2 3 4	M F		1 2 3				

CLEARED:

HOSPITAL NOTIFIED: YES NO

PATIENT: DOCTOR:

DISREGARD BY:

SPECIAL CALLS:

AT:

DISPATCHER:____________________

Figure 4. Dallas, Texas "AMBULANCE DIVISION ALARM REPORT"

CONCLUSIONS AND OBSERVATIONS

The substantive output of this research effort is embodied in illustration of an MBO application to EMS systems, the result of the application, comments relevant to the result, and a comparison of existing data use for management and the idealized concept of MBO. The MBO process was not applied in strict adherence to the guidelines presented in this report, and the results are in need of validation in real and operational environments. The comments of thirteen EMS system authorities are useful, as are the site visit reports, but the scope and magnitude of both efforts is inadequate to support any conclusive statement.

There are three general observations that can be made from this research effort which lend support to a recommendation for further study and a test application of MBO to evaluate EMS performance in a functioning EMS system. These observations are listed below:

1. Conceptually, Management by Objectives can be applied to the EMS system in a manner that allows for the development of objectives to describe all major functions of the system .

2. Although there are several potential problems associated with collection of the data proposed in this report, most consultants feel that the data would be useful.

3. Existing data collection in many EMS systems cannot be specifically related to management of the system.

Several facets of the MBO/EMS application remain to be investigated. The methodology of this analysis appears to be an appropriate guide for future analysis. Specifically:

1. A test site that incorporates <u>all</u> functions of an EMS system should be chosen.

2. An appropriate method for MBO application should be selected. There are alternatives to the Nominal Group Process (NGP), and although there appear to be considerable advantages to the NGP, other methods should be explored.

3. The method of MBO application should be applied to yield objectives, data, and goals.

4. Data collection systems should be designed to accommodate the data needs, tested, de-bugged and implemented. Data collection and managerial processes should be consistent and interdependent.

5. Parallel measures should be developed, possibly at another test site.

6. The MBO-derived performance assessment scheme should be evaluated over time.

The nature of MBO precludes the adoption of generalized goals that would be applicable to all systems, since constituents of the system should be involved in the definition of objectives and the establishment of goals. However, the data and objectives derived for the test application might be circulated among several EMS systems. The comments received from only a few consultants,via the EMS system Objectives and Data Assessment Survey, were valuable and can provide insight valuable to goal setting and data collection design efforts.

Rather than review subsequent MBO application in site visits, a seminar/discussion is suggested. The MBO concept is complex and may warrant efforts to educate and orient reviewers prior to discussion of the application at any particular site.

Appendix A: Nominal Goup Process of the Program Planning Model

Leader Format

The Nominal Group of the Program Planning Model is a meeting in which a deliberate structured group process is followed to identify problems or to generate information concerning a topic from a target group of individuals.[1] The structured process includes the following sequence of small group activity: (a) silent generation of ideas in writing, (b) round-robin listing of ideas on flip-chart, (c) serial discussion of ideas, (d) silent listing and ranking of priorities (preliminary vote), (e) discussion of vote, and (f) silent re-rank and rate of priorities. This structured process is critical, and is based upon social-psychological research which indicates this procedure is clearly superior over conventional discussion groups in terms of generating higher quality, quantity, and distribution of information on fact-finding tasks.[2]

The following step-by-step group leader format should be closely followed in the meeting.

I PREPATORY TASKS

A. Prepare meeting room: The meetings should take place in a large comfortable room. Three large tables with 5-7 chairs around each table should be well spaced near 3 of the 4 corners of the room. A large flip chart is placed at the head of each table. (See diagram for meeting room arrangement.)

B. Supplies to be brought to site: 3 flip-charts or large sheets of of paper, 3 x 5 cards, nominal group forms, 3 black and 3 red felt marking pens, masking tape, pencils, coffee, coke for break.

II LEADER's INTRODUCTION - 10 minutes

A. Welcome - Leader establishes sincere rapport with group members.

1. Explicitly request complete cooperation and commitment to the seriousness of the task at hand.
2. Theme of the meeting is to be "problem-minded", not "solution-minded".

   Make it very clear participants must direct attention to problems--not solutions, gossip, status or position of participants.

B. Purpose: Statement of Task:
This is the question that all participants are asked to respond to in the meeting.

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[1] A complete description of the program planning model is found in A. Delbecq and A. Van de Ven, "A Group Process Model for Problem Identification and Program Planning", forthcoming in Journal of Applied Behavioral Science, (September, 1971).

[2] A complete treatment of the social-psychological dynamics of nominal and interacting groups is available in A.Van de Ven and A. Delbecq, "Nominal and Interacting Groups for committee Decision-Making Effectiveness," Forthcoming in Academy of Management Journal (1971).

(Experience suggests that the appropriate wording of the task statement is crucial in order to obtain the focused response desired of participants. Prior to the meeting much serious thought regarding the question, "What information do you really want from the participants?" can guide the program staff in determining the task statement.)

C. Clarify Task Statement:

1. Pass out nominal (silent) activity forms. (The nominal activity form states the question each participant is to respond to in writing.)
2. Repeat question--state, specific critical incidents are desired.
3. Explain the kind of responses desired by using an example outside of participant's culture which they can identify with.
4. Resist further clarification. (To give further examples will bias participant's statements of problems.)

D. Nominal Group Guidelines:

To facilitate fullest participation of all members of the group the nominal, or silent, group exercise will be used. "The process will allow each participant an opportunity to do his homework."

1. Critical incident responses should be written in short words or phrases--not long paragraphs.
2. Each person will work silently and independently.
3. Again, stress that participants identify only critical incident problems, not solutions.
4. After the nominal group activity, each individual will be given a chance to discuss what he wrote on his sheet of paper.
5. Again, ask for cooperation and commitment to the task at hand.

III NOMINAL GROUP ACTIVITY - 15 minutes

A. Procedure:

Request participants to begin writing on the "nominal activity forms."

B. Leader Caveats:

1. Request participants to think more deeply if they have finished early.
2. Use forceful and direct sanction to those who talk, giggle.
3. State, people who have stopped writing not to interfere with others (not looking at violator.)

IV RECORDED ROUND-ROBIN-PROCEDURE - 30 minutes

A. Assignment of Group Recorders:

The group leader should act as recorder for the group, and write all ideas as presented by the group on a flip chart. If there are more groups than leaders request the leaderless groups to pick a recorder to write items on a flip chart.

B. Procedure:

1. Request participants in the group to present the items which they listed on their nominal forms--one item at a time for listing on the flip chart. (The leader writes each item as stated by the participant on the flip chart without allowing for argument on form, and without worrying about overlap. A showing of hands can be used to tally over duplication. Each item is numbered on the flip chart.)
2. Ask participants when their turn comes to alternate columns in listing items from the nominal activity forms.

C. Leader Caveats:

1. Group recorders should avoid categorization and redefinition of items.
2. Avoid discussion on items--simply list items on flip-chart.
3. Ask participants not to talk out of turn.
4. A show of hands should be used to tally agreements.

VI DISCUSSION

A. Discussion of items on flip-charts -- 15 minutes

1. Ask group to discuss items on flip-charts for clarification.
2. Do not collapse or condense categories.

VII VOTING PRIORITIES[3]

A. Listing and Ranking Priorities - 10 minutes

1. Request each participant to list nominally on 3 x 5 cards (by name and number) those items on the flip chart he considers most important. One 3 x 5 card is used for each item listed.
2. Request participants to rank their 3 x 5 cards in order of importance. (Leader should "walk participants through" the ranking process).
3. Collect 3 x 5 cards, tabulate votes on the flip-chart, and share resluts with the group.

---

[3] The specific voting procedure depends upon the degree of specificity information desired from the group, and the nature of the topic under investigation. If the topic is very general, and only preliminary information is desired a simple listing of priorities is sufficient. If a more detailed understanding of priorities in order of importance is desired a ranking of priorities is appropriate. If one desires understanding of the magnitude of difference between priorities, a rating of priorities is recommended. Since the rating procedure implies a listing and ranking of priorities, the rating process is outlined in the format. Necessary modifications for just a listing or ranking of priorities is left to the leader.

B. Discussion of Ranked Priorities: 10 minutes
   1. Ask group to discuss this ranking of priorities.
   2. Does everyone understand what is meant by each priority?
   3. Are there any items on the flip-chart that you think should be included in the problem priority list? Why?

C. Re-Ranking and Rating Priorities: 10 minutes
   1. Request each participant to nominally (silently) re-rank (by name and number) in order of importance those items on the flip chart that he considers most important.
   2. Ask each participant to nominally (silently) rate his re-ranked set of priorities.

      By the rating procedure, each participant is asked to assign and write a value of 100 to his most important priority card.* He then assigns and writes values between 0 and 100 on the other priority cards in his set so as to reflect relative differences in importance between items.

   3. The re-rankings and rating of priorities are collected, and need not be shared with the group.

VIII CONCLUSION -- 5 minutes

A. Collect all materials used during the meeting, including: (1) flip-charts and flip-chart sheets, (2) re-ranking and rating cards. (Have paper clips or rubber bands available to avoid mixing each participant's priority cards with others.)

B. Follow-up: The leader clearly states the reason the information was obtained in this meeting was to more clearly understand client problems (or critical issues of a problem area). Do not raise expectations of participants to a particular course of action.

C. Participants are thanked, and the meeting concludes.

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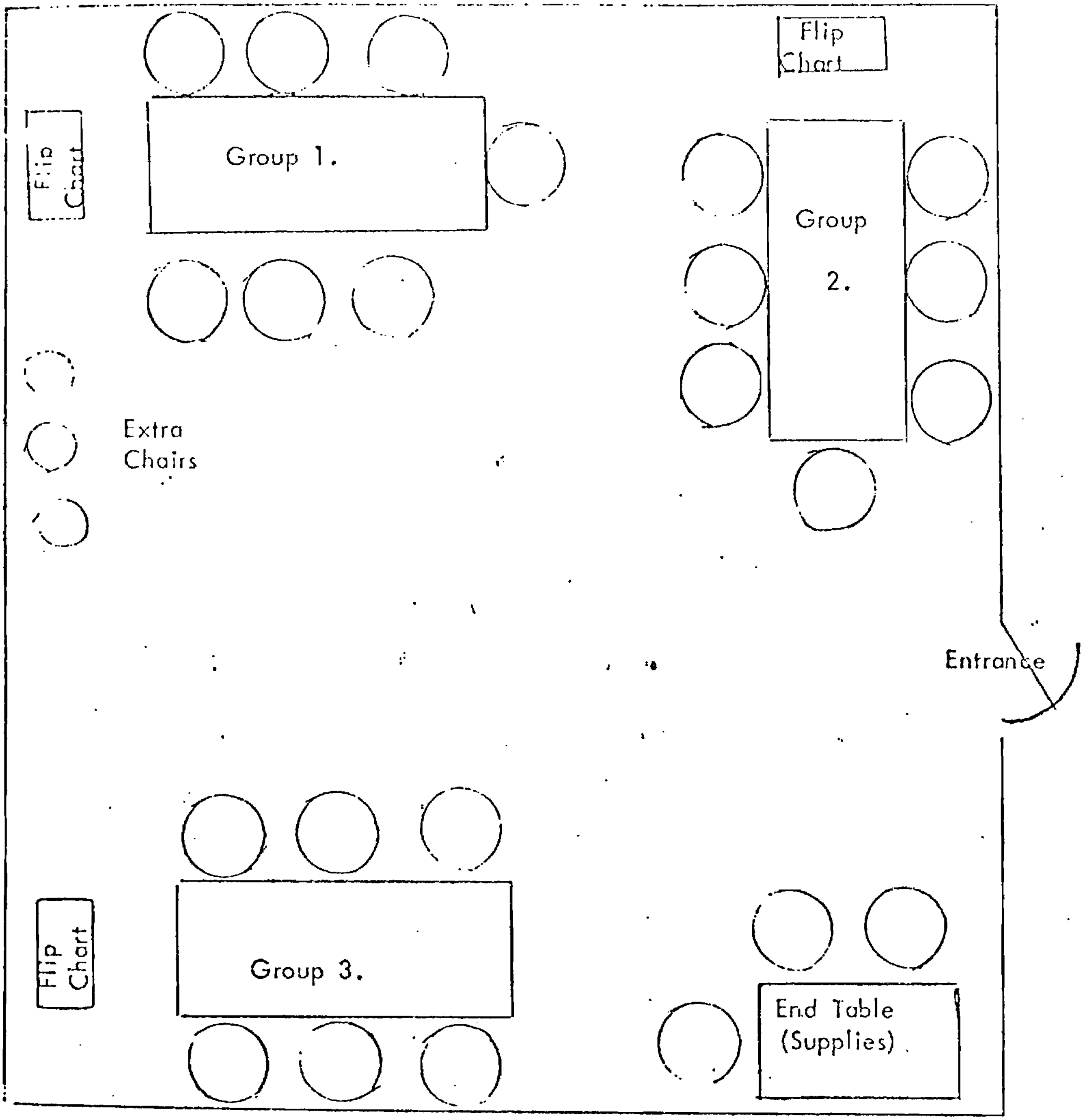
*An exemplary rating form that may be used is attached to this Leader Format.

May, 1971
University of Wisconsin

MEETING ROOM ARRANGEMENT

FOR THREE NOMINAL GROUP

MEETINGS



Exemplary Rating Form

100 MOST IMPORTANT

MODERATELY IMPORTANT

0 OF NO IMPORTANCE

Appendix B: Minimal Data List

A minimal list of performance data required to evaluate an EMS system has been extracted from the thirty-nine subsystem objectives/goals specified in a preceding section of the present report. These data are aggregated below*:

1. Requests where medical incident did not require emergency assistance. (E-1)
2. Total requests for medical assistance. (E-1)
3. Non-emergency entries. (E-2)
4. Total entries. (E-2)
5. Medical emergency entries. (E-3)
6. Total medical emergencies. (E-3)
7. Appropriate entry-point attempts. (E-4)
8. Total entry attempts. (E-4)
9. Time of perception of need for medical assistance. (E-5)
10. Time of initial contact at entry point. (E-5, E-6)
11. Time of completion of information transmittal to Dispatch Subsystem. (E-6)
12. Reports for which information is adequate to accurately determine the nature of the medical incident. (E-7)
13. Total medical incident reports. (E-7)
14. Accurate reports of the nature of the medical incident transmitted to Dispatch Subsystem. (E-8)
15. Total reported, apparent emergencies. (E-8, E-9, E-10, E-11, FC-1)
16. Obtained and transmitted accurate patient-volume information. (E-9)

---

*Each item of data is followed by an abbreviated notation that identifies from which subsystem objective(s) that particular item is derived. The letter(s) [e.g., "E"] indicate(s) the subsystem, and the number indicates the specific objective within that subsystem. The following subsystem abbreviations have been used throughout this list: E = Entry subsystem; D = Dispatch subsystem; RT = Resource Transportation subsystem; FC = Field Care subsystem; and F = Facility subsystem.

17. Obtained and transmitted accurate location information. (E-10)

18. Obtained and transmitted accurate environmental control information. (E-11)

19. Time of receipt of all medical incident information. (D-1)

20. Time of completion of dispatch command. (D-1, RT-1)

21. Medical incidents with an appropriate quantity and mix of EMS resource-units dispatched. (D-2)

22. Total requests from the Entry Subsystem for emergency medical assistance. (D-2)

23. Required status information reports received. (D-3)

24. Total required status information reports. (D-3)

25. Time of arrival at medical incident scene. (RT-1, FC-3)

26. Odometer reading at initiation of vehicle response. (RT-2)

27. Odometer reading at completion of vehicle response. (RT-2)

28. Time of initiation of vehicle response. (RT-2)

29. Time of completion of vehicle response. (RT-2)

30. Applicable responses without warning devices. (RT-3)

31. Total applicable responses. (RT-3)

32. Standard equipment item not transported. (RT-4)

33. Standard equipment item not operable. (RT-4)

34. Standard equipment item required. (RT-4)

35. Standard equipment item not required. (RT-5)

36. Total completed responses. (RT-5, RT-6)

37. Standard equipment proves inadequate. (RT-6)

38. Time of completion of medical responsibility. (RT-7)

39. Time of completion of "available" status report. (RT-7)

40. Reported, apparent emergencies where appropriate field care is initiated before the arrival of EMS field care resources. (FC-1)

41. Incidents where triage is performed without error. (FC-2)

42. Total medical incidents where triage is applicable. (FC-2)

43. Time of initiation of diagnostic function. (FC-3, FC-6)

44. Significant ailments diagnosed. (FC-4)

45. Total significant ailments. (FC-4, F-4)

46. Appropriately treated significant ailments. (FC-5)

47. Total diagnosed, significant ailments. (FC-5)

48. Time of completion of treatment function at the medical incident scene. (FC-6)

49. Correct patient referrals. (FC-7)

50. Total patient referrals. (FC-7)

51. Time of initiation of patient transport to emergency facility. (FC-8)

52. Time of arrival at appropriate emergency facility. (FC-8)

53. Odometer reading at initiation of patient transport by vehicle. (FC-9)

54. Odometer reading at completion of patient transport by vehicle. (FC-9)

55. Time of initiation of transport by vehicle. (FC-9)

56. Time of completion of transport by vehicle. (FC-9)

57. Incidents of inappropriate use of warning devices. (FC-10)

58. Total patient transports. (FC-10)

59. Patients triaged accurately. (F-1)

60. Total patients entering the facility. (F-1)

61. Time of entry into facility. (F-2)

62. Time of completion of triage function. (F-2, F-3)

63. Time of initiation of diagnostic function. (F-3, F-6)

64. Accurately diagnosed significant ailments. (F-4)

65. Appropriately treated diagnosed, significant ailments. (F-5)

66. Total diagnosed, significant ailments. (F-5)

67. Time of completion of treatment function. (F-6, F-8)

68. Accurate patient referrals. (F-7)

69. Total patient referrals. (F-7)

70. Time of completion of referral function. (F-8)

Appendix C: EMS System Objectives and Data Assessment Survey

Presented in this appendix are the introductory materials of the EMS System Objectives and Data Assessment Survey, including one example of the survey questions posed to the EMS Administrator consultants (Figure 1). The questions presented in the example are applicable to all objectives and data and are presented separately with each objective and corresdonding data in the actual survey instrument.

EMS SYSTEM OBJECTIVES AND DATA ASSESSMENT SURVEY

Survey Format

The purpose of this survey is to obtain: (1) your comments regarding the utility of the data described herein, to be used to evaluate EMS system performance; (2) your estimate of the difficulties that you believe would be encountered in collecting these data; and (3) your general thoughts or impressions with respect to each EMS system performance objective, and the entire set of data, reviewed collectively.

The format for each of the first thirty-nine pages of this survey is identical--i.e., each consists of four basic components (see Figure 1):

A. Subsystem objective.

B. Determination of the performance goal (x%, t minutes, etc.), which, in turn, indicates what data are to be collected.

C. Explanatory comment.

D. Questions pertaining to the corresponding objective and data.

The EMS System

The performance objectives addressed in this survey apply to an EMS system that has been subdivided into five, functionally-defined subsystems (see Figure 2). These subsystems are described as follows:

a. Entry Subsystem: This subsystem is composed of components that affect the receipt and transfer of information which describes each medical emergency from (and including) the perception of need to the EMS dispatch function.

b. Dispatch Subsystem: This subsystem is responsible for the analysis of the emergency request information and the subsequent initiation of a response to the emergency. Subsystem activities include the dispatch of personnel and equipment and the coordination and control of these resources.

c. Resource Transportation Subsystem: The components of the EMS system that affect the conveyance of the dispatched resources to the emergency scene are included in and define this subsystem. In addition, it is the responsibility of this subsystem to ensure that both vehicle and equipment are in good working order.

Figure 1. Basic Components of the Survey Format

Entry Subsystem

1. Limit the number of non-emergency requests for medical assistance to no more than x per cent of the total requests for medical assistance. A

$$\text{Goal} \leq x\% = \frac{a}{b}$$

Where: a = requests where medical incident did not require emergency assistance

b = total requests for medical assistance

B

Data indicate the effectiveness of all programs and other efforts to limit requests for EMS assistance to only medical emergencies. C

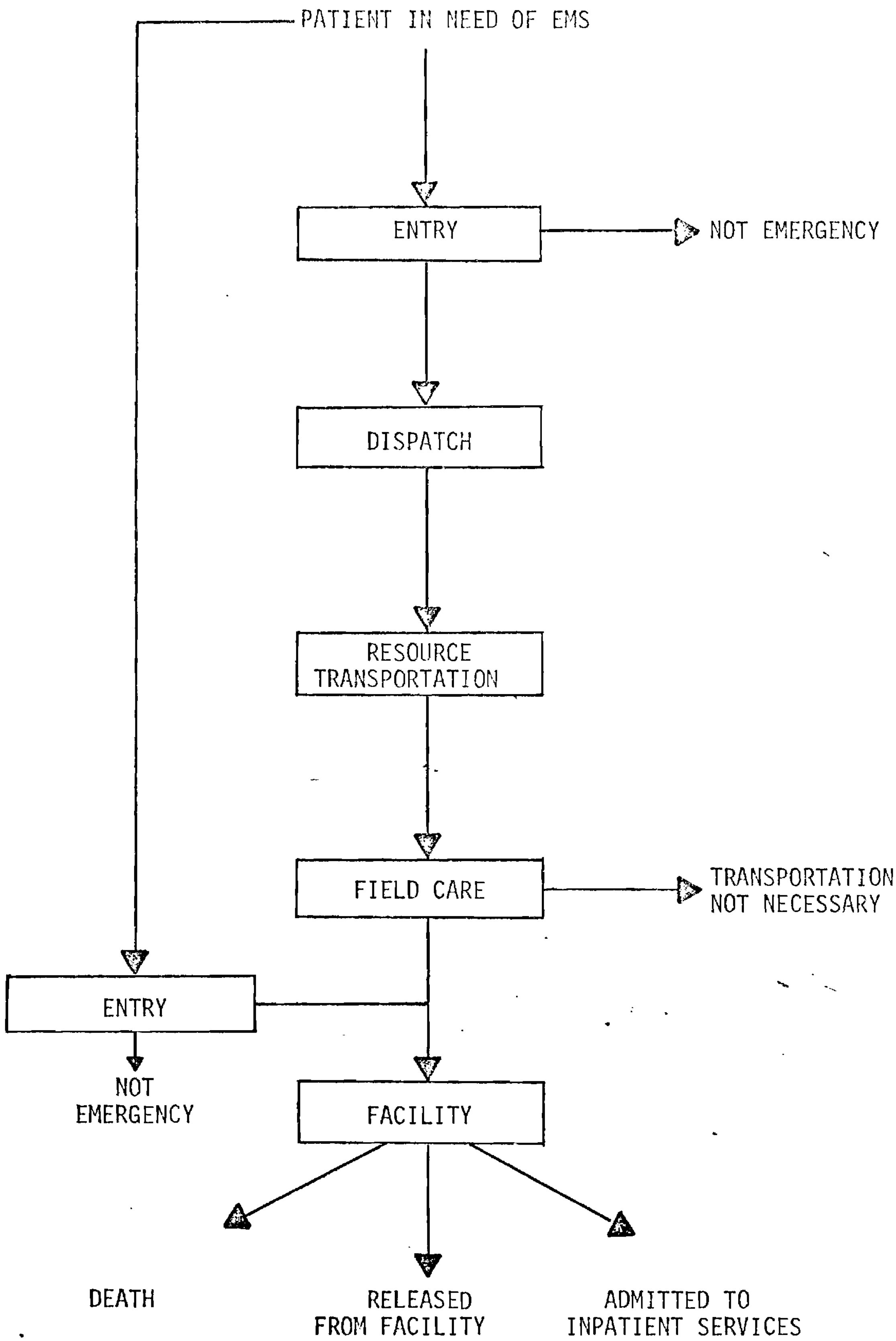
a. Do you perceive any problems (cost, feasibility, etc.) in the collection of these data? If so, what are they?

b. What is your perception of the data's utility for the evaluation of an EMS system?

c. Other comments and/or recommendations:

D

Figure 2. Functionally-Defined EMS Subsystems



d. Field Care Subsystem: This subsystem is composed of those system components invloved in the management of an emergency at the medical incident scene, and if necessary, during the transportation of the victim/patient from the scene.

e. Facility Subsystem: Those components required to provide emergency medical care within a fixed facility, usually a hospital's ED or CCU, compose this final subsystem.

Definitions and Clarification

Each of the following definitions and clarifying comments pertain to more than one subsystem objective and have been grouped together for the purpose of furnishing background information and for convenient reference:

1. Pertaining to Entry Objectives 9, 10, and 11; and Field Care Objective 1.

   Information pertaining to patient-volume, medical incident location, environmental control, and first-aid directions should neither be obtained nor transmitted unless the Entry Subsystem concludes that a medical emergency apparently exists.

2. Pertaining to Resource Transportation Objectives 4, 5, and 6.

   Standard Equipment: Equipment to be transported by a particular resource-unit during all emergency responses. "Equipment" is defined in its broadest sense--i.e., to include items ranging from bandages to oxygen tanks to, even, medical personnel.

3. Pertaining to Resource Transportation Objectives 5 and 6.

   Complete Response: Successful transportation (without disabling mechanical failure) of a resource-unit to a scene where a patient exists.

4. Pertaining to Field Care Objectives 2, 3, 4, 5, 6, and 7; Facility Objectives 1, 2, 4, 5, 6, 7, and 8.

   All performance data pertaining to either accuracy or speed of the triage, diagnosis, treatment, or referral functions (both field care and facility) can be used to evaluate the relative competence of the medical personnel involved and, in turn, their training/education program.

5. Pertaining to Field Care Objectives 4 and 5.

   Significant Ailment: The "significance" of an ailment must be determined in a subjective manner. A simple digital fracture might not be considered "significant" if the same patient were suffering from shock. However, a digital fracture could be deemed "significant" if the patient suffered from no other ailments. The definition of "significant ailment" is applicable to the diagnostic and treatment functions at the medical incident scene and also the emergency facility.

6. Pertaining to Field Care Objective 6 and Facility Objectives 3, 6, and 8.

   Performance goals for the time consumed by diagnosis, treatment, or referral must be adaptable to a wide variety of medical problems. For example, diagnosis of a gunshot wound of the head should consume less time than diagnosis of possible hairline, vertebral fracture. The establishment of a separate goal for each conceivable medical emergency would be undesirable due to economic and data management constraints. Goals can be established for "categories" of medical emergencies. Each medical emergency can be assigned to one of a limited number of categories, which could have separately determined goals for speed: e.g., ranging from "most urgent" (Category I) to "least urgent" (Category *n*).

Survey Directions

- Please record a response in the appropriate space for each and every question, regardless of the possible brevity of a certain response. For example, a simple "no foreseeable data collection problems" comment (rather than a blank space) will assure us that that question has been addressed.

- If your comments on individual questions extend beyond the space provided, please continue on the reverse side of that page and/or on the blank pages provided at the end of the survey.

* 1. Mr. Jeff Caskey
Associate Director
S. W. Alabama Planning Council
Mobile, Alabama

2. Mrs. Beverly Doyle
Training Supervisor, Medical Coordinator
Central Ambulance Service
Tulsa, Oklahoma

3. Dr. William Duncan
Director
Ambulatory Services
Wilmington, Delaware

4. Mr. Peter Ehrlich
Senior Health Planner
Health Planning Council
Miami, Florida

5. Mrs. Lynn Emerich
Project Manager
Emergency Medical Services Project
Upper Peninsula Comprehensive Health Planning
Marquette, Michigan

* 6. Mr. James Garvin
Coordinator
Metropolitan Emergency Medical Services, Inc.
Atlanta, Georgia

7. Mr. Ralph Gode
Regional Representative
White Plains Regional Office
New York State Department of Health
White Plains, New York

8. Mr. Stanley Grant
Administrator
Health Services Emergency Systems
Los Angeles, California

* 9. Capt. John Higgins
Emergency Services
Fire Department
Columbus, Ohio

10. Chief Bert Lugannani
Cincinnati Fire Division
Cincinnati, Ohio

11. Dr. Sylvia Micik
Director
Emergency Medical Services
San Diego, California

12. Mr. Jerry Montgomery
Director
Emergency Medical Services Division
Seattle, Washington

13. Mr. James O. Page
Chief
Office of Emergency Medical Services
Raliegh, North Carolina

* 14. Mr. Lawton Parrish
Director
Dougherty County Emergency Medical Services
Albany, Georgia

* 15. Mrs. I. M. Reed
Assistant Director for Systems
Department of Surgery
UAB
Birmingham, Alabama

16. Mr. Lawrence Riley
Administrator
Emergency Medical Services
Fort Wayne, Indiana

17. Mr. B. G. Roberts
Division Chief
Fire Department
Dallas, Texas

18. Mr. John Rowland
Director
Division of Emergency Medical Services
Pennsylvania Dept. of Health
Harrisburg, Pennsylvania

*Site did not return survey form.

Appendix D: Recipients of EMS System Objectives and Data Assessment Survey

*19. Dr. Robert Shaver
Director
Emergency Medical Services
Louisville, Kentucky

*20. Mr. Jack P. Webb
Battalion Fire Chief
Emergency Ambulance Service
District of Columbia Fire Dept.
Washington, D.C.

*Site did not return survey form.

Appendix E: EMS Subsystems Objectives

This appendix consists of a listing of the objectives developed for each functionally-defined EMS subsystem.

Entry Subsystem

1. Limit the number of non-emergency requests for medical assistance to no more than x per cent of the total requests for medical assistance.

2. Limit the number of non-emergency entries to no more than x per cent of the total entries.

3. Increase the number of medical emergency entries to at least x per cent of the total medical emergencies.

4. Cause appropriate entry-point attempts to equal at least x per cent of the total entry attempts.

5. Cause the time between perception of need for medical assistance and receipt of a request for medical assistance to be within x minutes.

6. Interrogate persons who report a medical emergency and transmit pertinent information to the Dispatch Subsystem in no more than x minutes.

7. Obtain information to accurately appraise the nature of the medical incidents for at least x per cent of the reported medical incidents.

8. Transmit to Dispatch Subsystem an accurate report of the nature each reported medical emergency for at least x per cent of the reported, apparent emergencies.

9. Obtain and transmit accurate patient-volume information for at least x per cent of the reported, apparent emergencies.

10. Obtain and transmit accurate descriptive location information required to locate precisely the medical incident scene in at least x per cent of the reported, apparent emergencies.

11. Obtain and transmit accurate environmental control information in at least x per cent of the reported, apparent emergencies.

Dispatch Subsystem

1. Analyze emergency assistance request information from the Entry Subsystem and notify the Resource Transportation Subsystem within x minutes.

2. Dispatch an appropriate quantity and mix of EMS resource-units for at least x per cent of the requests for emergency assistance.

3. Receive at least x per cent of the required status information reports from the Resource Transportation and Field Care Subsystems.

Resource Transportation Subsystem

1. Transport dispatched EMS resource-unit to medical incident scene within x minutes after receipt of command.

2. Transport dispatched EMS resource-unit to medical incident scene at an average speed not to exceed x miles per hour.

3. Limit applicable responses without the use of warning devices to no more than x per cent of total responses.

4. Limit the number of incidents where an item of the resource-unit's standard equipment is either not transported or inoperable to no more than x per cent of the incidents where such an item is required for patient care.

5. Limit unnecessary transportation of each item of the resource-unit's standard equipment to no more than x per cent of the total completed responses.

6. Limit the number of incidents where a resource-unit's standard equipment proves to be inadequate for patient care to no more than x per cent of the total completed responses.

7. Return to "available" status in no more than x minutes after medical responsiblity has been relieved at the medical incident scene or emergency facility.

Field Care Subsystem

1. Cause appropriate field care to begin prior to the arrival of EMS resources in at least x% of the total reported, apparent emergencies.

2. Perform triage without error for at least x per cent of applicable medical incidents.

3. Complete triage function within x minutes after arrival at medical incident scene.

4. Accurately diagnose at least x per cent of the patient's total significant ailments.

5. Appropriately treat at least x per cent of the patient's diagnosed, significant ailments.

6. Complete diagnosis and treatment functions at the medical incident scene within x minutes.

7. Correctly refer patients in at least x per cent of the total patient referrals.

8. Transport patients needing emergency facility care from the medical incident scene to the appropriate emergency facility within x minutes.

9. Transport patients needing emergency facility care from the medical incident scene to the emergency facility at an average speed not to exceed x miles per hour.

10. Limit inappropriate use of warning devices during patient transportation to no more than x per cent of total patient transports.

Facility Subsystem

1. Accurately triage at least x per cent of the total patients entering the facility.

2. Complete triage function within x minutes after the patient enters the facility.

3. Begin diagnosis within x minutes after the completion of the triage function.

4. Accurately diagnose at least x per cent of significant patient ailments.

5. Appropriately treat at least x per cent of diagnosed, significant ailments.

6. Complete diagnostic and treatment functions within x minutes.

7. Accurately refer the patient in at least x per cent of total patient referrals.

8. Refer patients within x minutes after the completion of the treatment function.

Appendix F: Instructions for the Dade County Rescue Incident Report

The Rescue Incident Report is a five (5) part form.

Original - Permanent Record
Yellow - Station File
 - Computer Data
Green - Hospital Copy (transmitted with patient)
White - Emergency Medical Service

This form is intended to provide an instrument for information gathering on the scene, a sequence of treatment, result and disposition of the patient. Also, included is a section where equipment, drugs, etc., may be listed and computerized. Hopefully this will aid in budgeting and stocking the many items now required to provide Emergency Medical Rescue Service. A separate form will be necessary for each patient, with the computer information and narrative on only one side.

Instructions for the Preparation of the Rescue Incident Report are as follows:

The portion that deals with the patients name and treatment is completed, on the scene and is a completed record of the aid given to the patient until he arrives, at the hospital or Rescue is no longer responsible. It may be done with a ballpoint pen and the remainder of the form completed in quarters. It is intended to be used as one form, not a field copy and done over back at the station. Therefore, it will be important to be neat. If the form becomes wet, blood stained, etc., of course it would need to be done over.

PATIENTS NAME: Very important if available

DEPARTMENT: Your department 901 number Miami 01 etc.

INCIDENT NUMBER: Must be entered on form at the scene. The alarm number preceeded by the digit 3 for 73 or 4 for 74. (Example; Alarm NR 1042-3001042)

PATIENTS ADDRESS: Important if available

RACE: Use the following codes:

S - Spanish B - Black
W - White O - Oriented

TRANSPORTATION: To be completed by ambulance unless you transport. If you transport, (Example; Miami Rescue 1 transports)

Department		Unit Number				
/0/	/1/	/0/	/0/	/4/	/0/	/1/
901 Code				901 Code		

DATE OF BIRTH: Very important for necessary follow-up of hospital records. Name and birth are essential.

AGE: A convenience

SEX: M - Male
F - Female

MEDICAL RECORD NUMBER

HOSPITAL EMERGENCY ROOM: This will be filled out by the hospital only on their copy of the report. If you follow the patient in and the Medical Record Number is available, fill it in.

RESCUE IMPRESSION: With the information, you have what illness or injury do you think you are treating the patient for; (Example: (1)possible heart attack, (2) possible hyperglycemia, (3) open fracture, (4) gunshot wound with possible internal bleeding, etc.)

WAS BLOOD DRAWN: Mark with an /X/ Yes or no

REMARKS: Any remarks that you think will be of value in the care of the patient. (Example; (1) previous heart attack '72'; (2) Known diabetic no insulin today; (3) patients regular medication digoxin, dilantin, etc,; (4) 2 nitro taken prior to our arrival.)

PATIENT VOMITED: Mark with an /X/ Yes or no.

PATIENTS COMPLAINT: If the patient is conscious, what he tells you bothers him the most, in cases of illness. (Example;(1) nausea (2) dull chest pain,(3) shortness of breath, (4) all over weakness.) In cases of trauma indicate the cause and complaint.(Example;(1) gunshot wound - short of breath (2) open fracture - severe bleeding (3) smoke inhalation unconscious (4) auto accident - chest pain.

BLOOD LOSS RATE: Mark with an /X/ HI - /X/ for a rapid loss of blood loss LO-/X/ for a slow loss of blood or small amount of blood loss.

EKG Radio Transmissions

EKG NUMBER: Use the numbers and letters you use for your city. (Example: Miami /M/ /1/ /3/ /4/ /8/ /9/)

Miami = M
Rescue 1 = 1
1973 = 3
Numerical Sequence = 4 8 9

NOTES: Shows EKG read-out as provided by the hospital (example (1) Normal sinus rhythem (2) PVC's (3) PAC's (4) 60 cycle interference no readout, etc.

TIME: Use a 24-hour clock (Example; 4:00 p.m. - 1600) you may record three separate tracings.

Transmission Sent To:

HOSPITAL: Which hospital was the telementry sent to.

HOSPITAL CODE: To be developed.

Sequence of Treatments and Vital Signs

The 21 items listed and coded are to be used in the blocks under TREATMENT GIVEN. All codes are two diget numbers and are to be inserted in a single block. (Example: /21/ would indicate CCCC Manual)

TREATMENT GIVEN: Initial condition would show the time vital signs were taken. Subsequent lines would show treatment given, with the time and vital signs recorded, hopefully showing improvement in the patients condition or stabilization in his condition. If you transport or accompany the patient show his vital signs at time of arrival at the medical facility.

CONSCIOUS: Indicate selection /X/

CON - Conscious
DRO - Drowsy
UNC - Unconscious

R: Respiration rate, show rate per minute /18/

P: Pulse rate, show rate per minute /80/

SKIN: Show skin color as substitute when no B/P reading is available.

CYN - Cyanotic
FLU - Flushed
ASH - Ashen or pale

B/P: Show actual blood pressure /160/90/

PUPIL: Show pupil reaction
DIL - Dialated
SLG - Sluggish
UNR - Unresponsive to light
UN - Unequal

TREATMENT AND AID GIVEN PATIENT

CODE: List all IV's drugs, bandages, splints, extrication tools, etc., showing quantities for hospital information. Code to be developed for all equipment carried by fire rescues for annual recall. (Examples shown on following page.)

CONT.

(Example:)

/0/	/1/	I. V. (D5W)	/0/	/9/	Emergi-Kit
/1/	/2/	Valium (1/2)	/8/	/9/	Fit Stick
/4/	/3/	Δ Bandage (4)			

ANATOMY INVOLVED

Show the area of trauma or pain with an X over the exact area of injury on the drawing. In the boxes provided, show the corresponding number in the boxes.

POS - Posterior
/7/
ANT - Anterior
/3/
INT - Internal
/5/

PATIENT SENT TO:

HOSPITAL NAME: Write out name

HOSPTIAL CODE: Fill in code back at quarters

PATIENT TRANSPORTED TO:

Show mode of transportation used tomove the patient to a medical facility.

AMB	/X/	Ambulance	AIR VEH	/ /	Helicopter, etc.
F/R VEH	/ /	Fire-Rescue Unit	CAB	/ /	Taxi
POL VEH	/ /	Police Car, etc.	PRI CAR	/ /	Any auto or truck used privately

NUMBER OF F/R AIDING TRANSPORTING OF PATIENT: Show the actual number of Fire Rescue Personnel involved in transportation by your unit or sent in an ambulance etc., to accompany the patient.

POSITION OF PATIENT: Show an /X/ in the appropriate box.

TIME LV. SCENE: Always show the time the patient left the scene for a medical facility.

TIME ARR. HOSP. If you transport or accompany the patient, indicate arrival time at the medical facility.

Appendix G: Objectives from Dade County

THE OBJECTIVES OF EMS COMMUNICATIONS SYSTEM

April, 1973

THE OBJECTIVES OF EMS COMMUNICATIONS SYSTEM

The purpose of the first few meetings of the Communications Committee is to define what it is we want a communications system to do. Who needs to talk to whom? What circumstances require special communications? What are the limitations, political and technical? And so on until we have a definite concept or plan as to what it is we want. Then we can proceed to talk about alternatives, equipment capabilities and the like.

Presented below is a listing of the various communication needs that were identified at the first meeting.

I. Medical Rescue

Medical rescue (usually provided by Fire Departments) is a service which provides fast response to emergency calls with trained paramedical personnel. These paramedics in radio contact with a physician are able to institute life saving measures including heart monitoring and injection of drugs. This service and the agencies providing this service require the following communication capabilities.

a. Physician consultation

At the scene of an emergency, the paramedics must have the ability to have two-way communication with a qualified physician.* This communication may include voice as well as biomedical data such as heart monitoring.

b. Coordination

The agency providing medical rescue has certain operational demands which require communication with its mobile units. This includes dispatching and controlling of mobile units and the receiving of calls from the public.

c. Ambulance

Medical rescue services in Dade County depend on a back-up ambulance service to provide medical transportation. Thus, the medical rescue unit must be able to request an ambulance.

d. Other Back-up assistance

If the medical rescue team at the scene find they are unable to handle the emergency alone, they must be able to request and receive back-up assistance. This assistance may be from police to handle traffic or crowds (front-end) or additional rescue or ambulatory service for medical care (back-end).

*A qualified physician is a physician who is (1) experienced in the field treatment of sudden attacks of disease and trauma and (2) knowledgable as to the capabilities of the medical rescue team.

II. Medical Facilities
There are over forty acute medical facilities (including clinics) in Dade County. These medical facilities vary in their capabilities to handle emergencies.* Therefore, their role in the community regarding emergency medical services varies also; and, so do their communication needs. However, all medical facilities have to some degree the following communication needs in relation to EMS:

a. Inter-hospital
Within a hospital there is always the possibility of an emergency. Like any large building with much pedestrian and vehicle traffic, there is always a constant threat of auto collision, heart attack, violence and so forth. Therefore, hospitals have security personnel as well as medical persons who must be available within a moments notice to respond to an in-hospital emergency.

In addition, the care of the sick and injured represents a particularly high risk of sudden medical emergencies. These will occur and every hospital must be prepared to respond with trained medical personnel.

Finally, a hospital must be able to call upon its medical personnel, particularly physicians, at any time. Such calls may be initiated by a single patient who is in trouble and the private physician should be consulted. Or, it may be a diaster situation and the hospital must prepare itself to receive casualties.

* In the near future, a survey of the emergency capabilities of medical facilities will be undertaken by the Task Force.

b. Intra-hospital Coordination
~~There is a need, particularly~~ in diasters for inter-hospital communications. This does not mean necessarily hospital to hospital. What it does mean is that one agency can communicate to all the hospitals, individually or collectively. This allows for inter-hospital coordination of resources, dissemination of factual information, and moment to moment knowledge of any hospital's capabilities.

c. Hospital (Physician) to field
1. Medical Rescue: The medical rescue services require physician consultation at the scene. In many cases, this physician consultation is provided by hospital-based physicians. For this reason certain hospitals require the capability to communicate with medical rescue.
2. Ambulance: A hospital (Emergency Department) can better handle emergencies if they know what to expect and when. Therefore, it is desirable to have ambulance to emergency department communications.

III. Ambulance Service

Ambulance service in Dade County is provided primarily by Randle-Eastern Ambulance Service, Inc. Randall-Eastern is required by contract to transport any emergency calls eminating from the Public Safety Department. Excepting certain municipalities, Randle-Eastern is the only provider of emergency medical transportation. The needs of Randle-Eastern in terms of communication are:

a. Notification

Notification refers to the receiving of requests for medical transportation. These requests may come from the public, from hospitals, fire departments. or police agencies. The need is for a notification center to receive these various requests.

b. Dispatching

Randle-Eastern, like the medical rescue services, must be able to communicate with its mobile units in order to control and coordinate them. This is commonly known as dispatching.

c. Medical Facilities

As noted above, hospitals can better prepare for incoming emergency victims if they know what is coming in and when. In order for this to be accomplished the ambulance vehicles must be able to communicate to the hospitals. This may mean direct voice communications of mobile to hospital or indirectly through a communications center which passes on the information.

IV. Disasters

Disasters represent special kinds of demands in terms of communications. A disaster for our purposes can be called any situation which, because of the nature or size of the emergency, is beyond the capacity or capabilities of the personnel on duty. Disasters, therefore require the assistance of additional support personnel and equipment. However, disasters come in all sorts of unexpected size, shapes, and characteristics. Thus, the exact type and number of personnel needed cannot be known until the disaster occurs. Agreed, we can estimate that a plane might require this and that but in the recent L 1011 crash how many of us would have thought of air boats before the incident? And what if there had been a fire?

There are two distinct needs which apply to disaster communications, resource gathering and resource coordination.

a. Resource Gathering

Resource gathering refers to notifying the various agencies and individuals who may be required to assist in the disaster. Put simply it means putting certain troops into the field and alerting others to be ready to receive casualties. To do this there must be prior identification of roles and responsibilities of various agencies. There must be a systematic process of data gathering, including data on the disaster itself (location, number of casualties, etc.) and data on availability of resources. Those agencies that would appear to play a role in a disaster situation are:

Hospitals
Law enforcement agencies
Fire and Fire Rescue
Military including Coast Guard
Civil Defense
Federal, State and local Governments and their agencies (FBI, Fish and Game, etc.)
Utilities including Florida Power and Light and Southern Bell
Private Groups organized to assist in disasters (Red Cross, REACT)

Any or all of these above agencies may be included in any disaster alert. Thus, there must be the capability of communicating quickly and efficiently with each of these agencies.

b. Resource coordination

The long list of independent agencies noted above is somewhat frightening to anyone contemplating coordinating resources. What one might expect and too often has been true is that there are often two disasters. The first is the plane crash, train wreck or boat collision. The second disaster is when all the various and sundry "rescuers" arrive en masse with little or no overall supervision, control and coordination.

The coordination of resources during a disaster requires two things: excellent communications and control. A communications command post fills both of these needs. This command post should be the hub of all activities, controlling the flow of resources, victims, and information. Much more will be said regarding disasters communications when the Task Force takes on this problem as a separate area of study.

V. Public Access

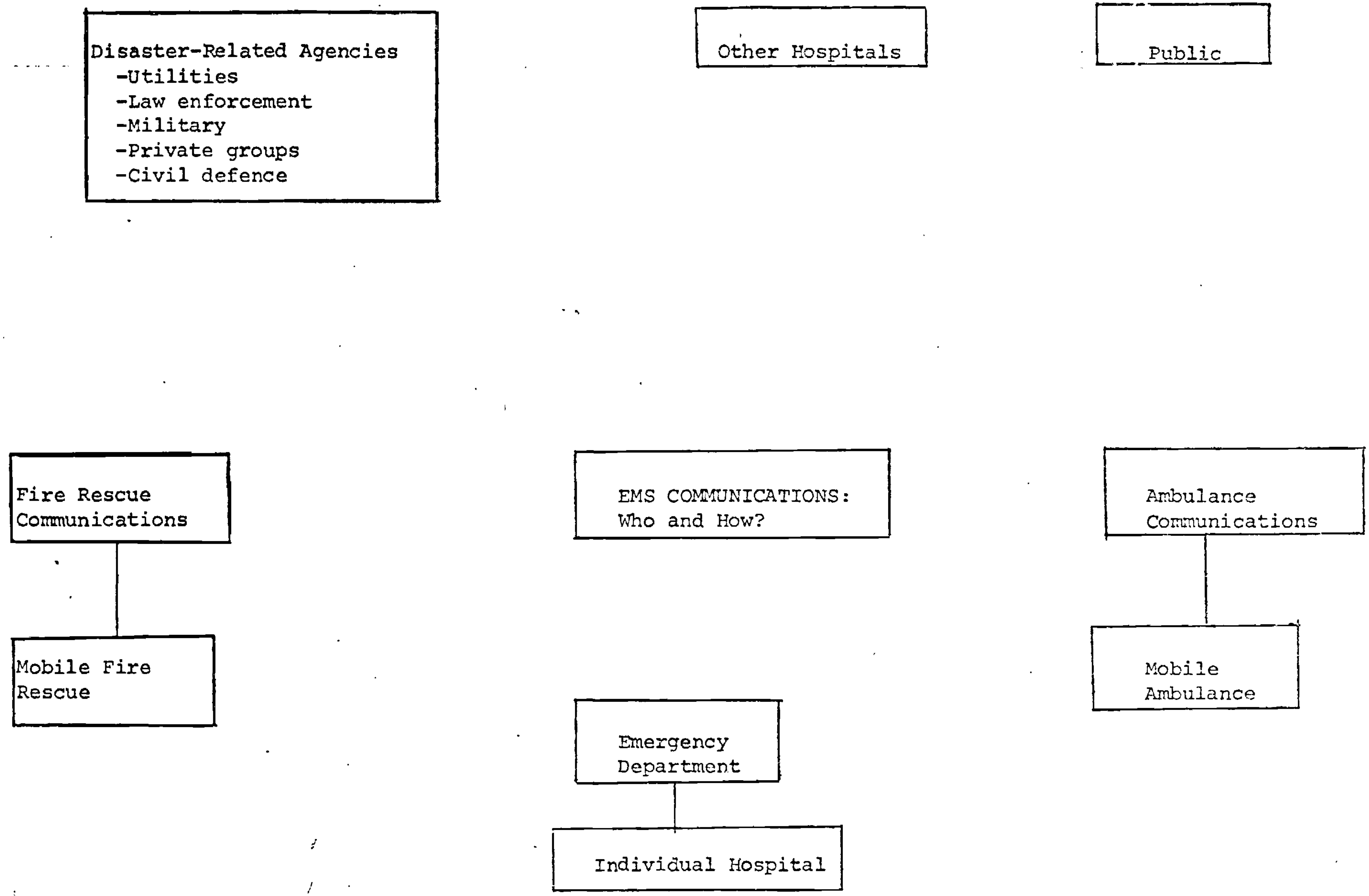
The EMS Task Force is presently involved in developing a system of emergency medical services. This system planning includes the clear identification of roles and responsibilities. It also includes mechanisms for control and coordination over the various components of the system. The one area or component seemingly beyond our control which can very well entirely upset all other parts of the system is the public component. How the public enters and uses the system is the key to the eventual success or failure of our planning.

It has been recommended that an international telephone number be utilized as the "emergency number". This number is 911 (nine-one-one). Many communities in this country have instituted the "911" number and its citizens now are able to receive emergency help easier, faster, and more efficiently. If Dade County develops the finest rescue system in the world, it will be less than the best if it does not allow for easy citizen access, preferably through a nationally recognized emergency number such as "911".

VI. Linking the components

In the proceeding pages, we have attempted to outline the various objectives or needs which an EMS communications system must meet. To complete this, these needs must be put into perspective. Comments must be made regarding the type and quality required for each communication link. For instance, is two-way voice necessary? Are land lines or "hot lines" sufficient? What are the situation variables which can effect the communications? Where should the communication lines begin? and end? Is there need for a coordinating communications center? What are our limitations?

These questions must next be discussed and answered by the committee. As a starting point, attached is a diagram of the possible linkages. At our next meeting we will need to firm up these linkages and begin answering our questions.


Disaster-Related Agencies
-Utilities
-Law enforcement
-Military
-Private groups
-Civil defence
Other Hospitals
Public
Fire Rescue Communications
EMS COMMUNICATIONS: Who and How?
Ambulance Communications
Mobile Fire Rescue
Mobile Ambulance
Emergency Department
Individual Hospital

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